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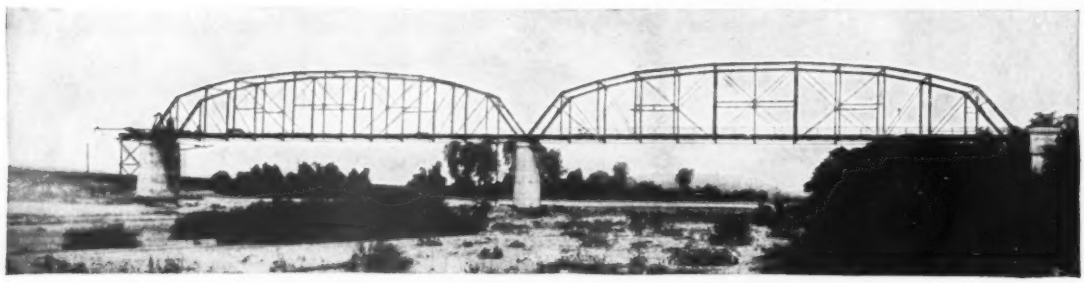

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259

Engineering News

VOLUME 76 OCTOBER 5, 1916 NUMBER 14

Capitol Terraces at Last Made Waterproof

The pavement over the terrace chambers of the United States Capitol at Washington, D. C., after years of effort has at last been made water-tight. Ever since the terraces were built, in 1856, each attempt except this last to prevent the down-leakage of storm water has been abortive.

As may be seen from Fig. 1, the terraces form a masonry esplanade on three sides of the Capitol. There are two levels connected at frequent intervals by short flights of steps. Along the edge of the upper terrace and between the steps are masonry plant cases. The chambers under the terraces at first were used as Congressional offices, but since the completion of the House and Senate buildings they have been used mostly as building-service rooms.

About every waterproofing scheme known has been tried on some part of this great expanse (about 200,000 sq.ft.) of walk—felt and tar pitch, asphalt and burlap, sheet asphalt, etc. Perhaps the most notable scheme employed up to the recent successful attempt was the use in 1906 of a sheet-lead pan placed under one section. The lead sheet was bedded on cement mortar on the base slab and was covered with a 3-in. reinforced-concrete slab and a 1-in. wearing surface. But even this construction was of no avail, partly because of the extreme expansion movement, partly because of unskilled burning of the sheet joints and partly because of the inherent difficulties of flashing around the vault light frames. The lead sheets on being uncovered were found to be considerably pitted.

The expansion and contraction of the terrace structure are excessive, owing to wide variations in temperature and extreme exposure. The walls on either end of the terraces were forced 2½ in. out of plumb. At least 60% of the Scotch granite stones on the plant cases were out of alignment, and the larger part of the marble balustrade had been forced out of line. All this distortion was due to insufficient provision for inevitable expansion movement, and to this defect can be finally traced the repeated failures to keep the terrace chambers

FIG. 1. THE CAPITOL AND TERRACES AT WASHINGTON, D. C.

water-tight. Final success was largely due to recognizing the expansion difficulties and providing for such movement by water-tight sealed expansion joints.

The Latest Attempt Successful

As a result of a final investigation in 1914, made by Elliott Woods, Superintendent of the United States Capitol Building and Grounds, and David Lynn, Civil Engineer, it was believed that a successful job could be secured. Specifications were issued and tenders were received, as a result of which the material and laying system of the Masonry Waterproofing Co., Brooklyn, N. Y., were selected as the most desirable for the conditions involved. The notable features of this concern's proposal (employing what is commercially known as the Sheffield or "Larutan" system) consisted (1) in securing a bituminous compound blended to secure maximum adhesiveness and cohesion, (2) in using small (1-sq.yd.) freshly saturated membrane sheets, with wide laps, mopped into place and armored, (3) in free use of special expansion and flashing joints.

The material over the terraces was removed down to the concrete slab over the floor arches. When the wearing surface was removed, there were found numerous fractures in the base slab, inevitably occurring in a structure of this sort. Each crack of this description was treated as an expansion joint. The cracks were cleaned out, heated with a gasoline torch, partly filled with compound and tooled with a hot iron—all as shown in Figs. 2, 3 and 4. The slab was also cut for expansion joints, as shown in Fig. 5.

After the expansion joints were filled, then the pavements were brought up to subgrade (about 6 in. above the brick supporting arches and base slab and about 2½ in. below finished grade) by a filling of 1:3:6 concrete. Upon the leveled subgrade were laid single sheets of impregnated cotton drill. The sheets were 1 yd. square and were laid with 2-in. laps. A small area of subgrade was cleaned and mopped with hot compound just previous to laying each sheet. The laps were made by following with a hot smoothing iron. To prevent the men's shoes from injuring the membrane while working, a little pile of sand was placed in the center of each sheet as laid. The men could easily walk from one sand pile to another. Upon the membrane thus made there was laid, as armor for the waterproofing and as a wearing surface, a granolithic pavement (1:1:2 mixture with ½- to ¾-in. washed bluestone chips), marked off in squares, separated by expansion joints continuous with the expansion joints in the sub-base, as shown in Fig. 5, along the balus-

FIGS. 2 TO 4. SLAB CRACKS MADE INTO EXPANSION JOINTS, CAPITOL TERRACES

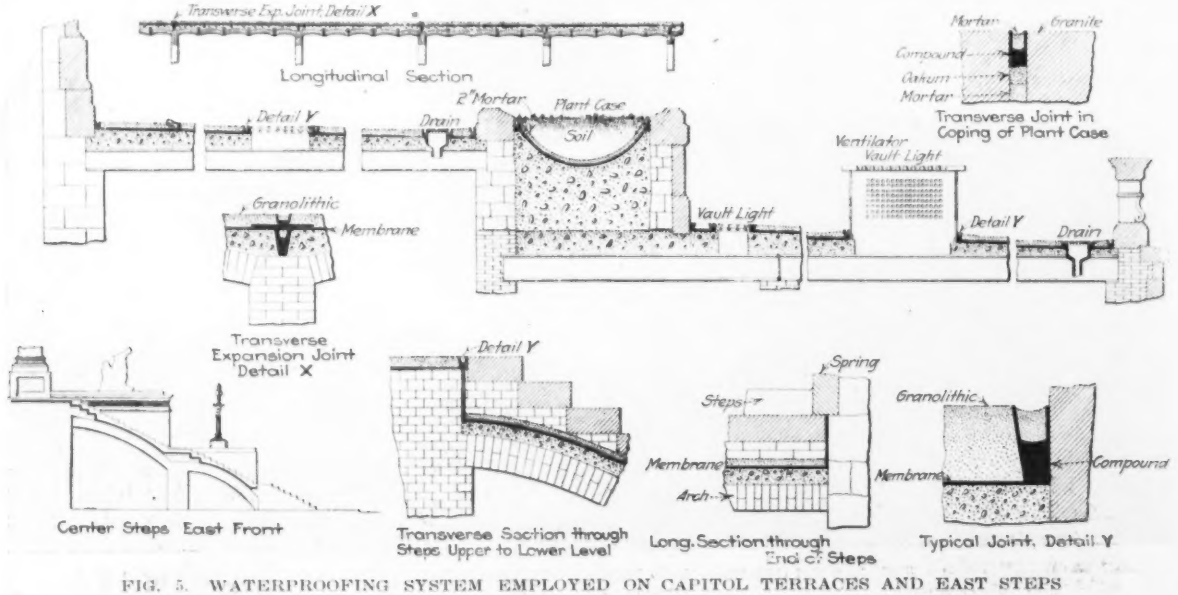
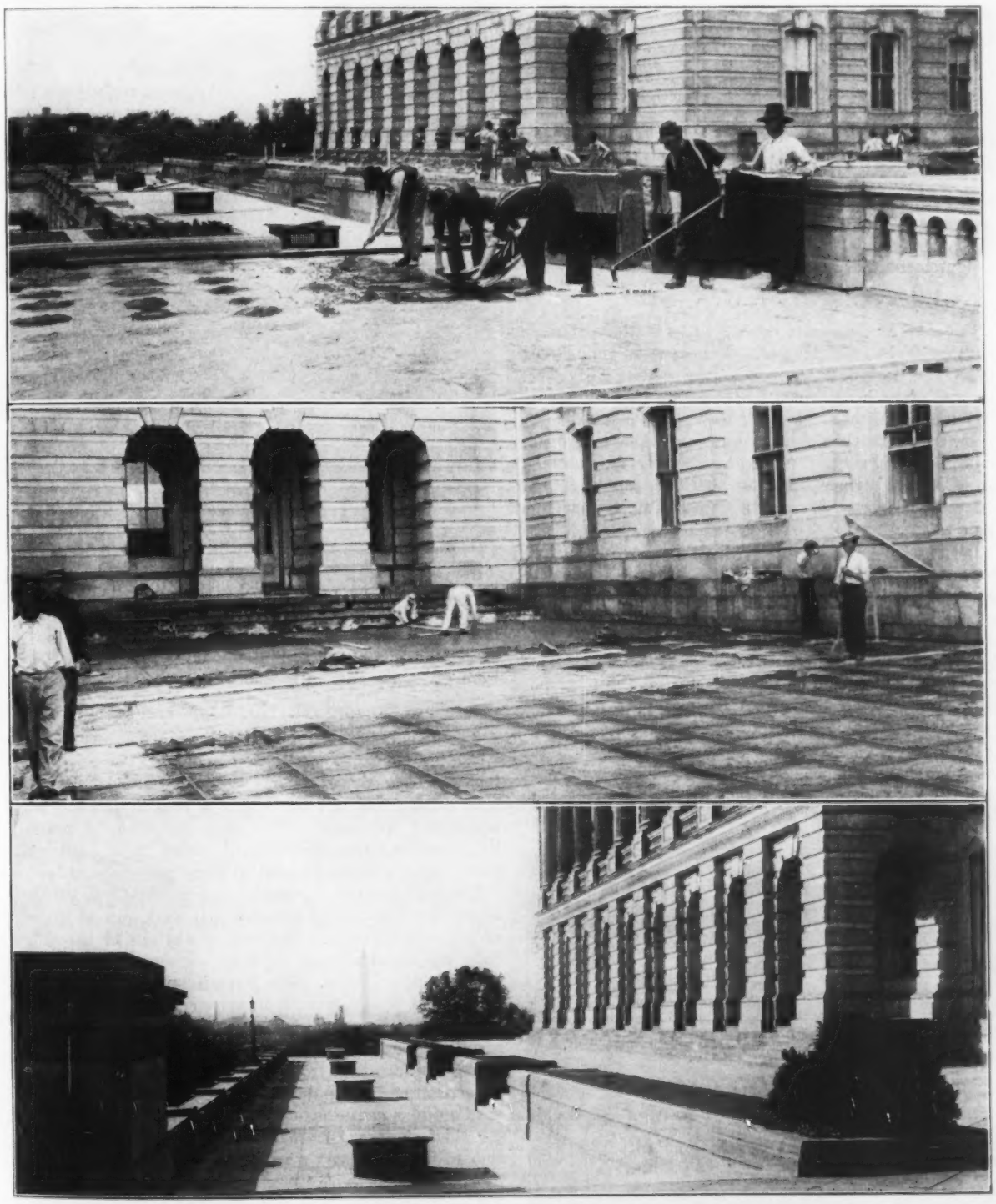


FIG. 5. WATERPROOFING SYSTEM EMPLOYED ON CAPITOL TERRACES AND EAST STEPS
Designed by the Masonry Waterproofing Co., Brooklyn, N. Y.; Oscar Sheffield, Chief Engineer

trades, vault lights and at every point where flashing would ordinarily have been employed. There was over 7,500 lin.ft. of these joints; not a piece of metal flashing was used on the work.

The expansion joints are of particular importance, interest and novelty. The cut in the bottom slab was heated, painted and partly filled with compound. Then the membrane was brought down into the reservoir and the joint pointed with mortar. The joint was covered with a patch strip (see detail on Fig. 5), completing the lower half. When the granolithic paving was laid, wood strips, tapered ¾ to ¼ in., were inserted as joint forms. When the concrete had set, the wood was pulled out, the opening heated and partly filled with compound. The remaining space was pointed with mortar. In this way a covered and sealed reservoir was created at each ex-



FIGS. 6 TO 8. WATERPROOFING THE CAPITOL TERRACES AT WASHINGTON
Fig. 6. (Upper)—Laying the membrane. Fig. 7. (Middle)—Placing granolithic armor on the membrane. Fig. 8. (Lower)—A corner of the completed terraces

pansion joint. As the structure contracts and expands, the mortar plug is drawn down or forced out, the seal being preserved. On inspection this summer the joints were found all closed nearly tight, demonstrating that by use of a thin plastic membrane underlying the wearing surface the latter could be kept from spalling or cracking.

Before the wearing surface was placed, it was decided to remove the old stone gutter which had been set in the old construction and which in some parts of the terraces was a stumbling block. To secure good drainage a slight valley was formed in the wearing surface with enough drains at intervals to carry off any downpour. The valleys are so slight as to be hardly noticeable to the pedestrian. During the past winter the entire area was drained so successfully that the usual slippery surfaces of earlier years were eliminated.

The scheme of using expansion joints along the edge of the paving eliminated the cutting of reglets in the marble balustrade and granite base and prevented the disfigurement that would have resulted.

Steps and Plant Cases

The steps leading from the higher to the lower terrace levels had to be reconstructed. The old steps were simply stone slabs or beams resting on pier walls. They were removed and a brick barrel built up (see Fig. 5) to support the stone. On the brick was placed a 4-in. layer of concrete; on this in turn was the waterproof membrane, laid as already noted, and finally on this 1½ in. of mortar armor. At last, on the completed and waterproofed barrel, brick steps were laid up to carry the stone treads.

The plant cases, being directly over the basement corridors, were made into water-tight basins. The earth-filling, existing waterproofing and a part of the concrete bottom were removed. First, new concrete was laid so as to give an elliptical basin—to prevent the freezing of the earth-fill from dislodging the sides. The waterproofing membrane was laid on the concrete and a 2-in. granolithic armor placed over it. A flashing joint was made between the concrete and granite coping stones, similar to the expansion joints on the terraces, already described, and the membrane was sealed into it. This joint was made to prevent leakage in the unexpected event that the coping stones were again moved out of alignment.

FIG. 9. WATERPROOFING PLANT CASES

FIG. 10. WATERPROOFING THE BARREL OF CAPITOL EAST STEPS

The chipped, scaled and cracked condition of the steps at the east front of the Capitol had been the subject of criticism for years. An appropriation was made for reconstructing these at the time of making the appropriation for waterproofing the terraces. The work was done at about the same time, and the vaults under the steps were given the same treatment.

Rebuilding the East Steps

These steps were originally built on a masonry barrel. After the old stone treads were removed, the brick filling was cleaned away down to the arch. An inch of lean mortar was put on to give a smooth bed for the waterproof membrane. Over this was 6 in. of granolithic armor. On the enlarged barrel thus built up, brick risers were constructed to carry new stone slabs.

The appropriation for the terraces was $83,500, but the tender for the desired material and work ran in excess of the appropriation. However, a way out of the difficulty was found without the delay necessary to increasing the amount available. The Superintendent of the Capitol, Elliott Woods, secured an agreement with the Masonry Waterproofing Co. whereby the concern's system and materials were used, but the actual labor was done under the Government payroll—the company's workmen (a supervisor and seven men) being temporarily hired by the Capitol Superintendent. In addition, Oscar Sheffield, the chief engineer of the company, gave personal attention to the work. As a result the work on the terraces proper was done with an expenditure of $67,000 out of the appropriation. The waterproofing of the east steps and other work not covered in the first specifications required $14,692, leaving an unexpended balance of $1,800.

Tunnels for Electric Cables*

In Chicago there are 12 tunnels for carrying power cables across the river and several others for telephone cables, gas pipes and water pipes. In Detroit, similar tunnels are used for getting conduits through alleys that are blocked near the surface by other structures.

The Chicago power and light tunnels are built in the shape of an inverted U with the vertical height 6 ft. 6 in. in the clear, and the width 6 ft., with 9-in. concrete walls. The tunnel has a slope of 1 or 2% toward a sump at the foot of one of the shafts, so that it can be pumped out as a preliminary to cable pulling. At each end of the tunnel is a shaft 6 ft. 6 in. internal diameter, with 15-in. concrete walls. At the upper end of each shaft is a manhole which forms the terminus of the conduits leading to and from the tunnel. It is found convenient to have the tunnel shaft extend 2 ft. above the bottom of the manhole, for convenience in working and as a protection to the workmen. A permanent galvanized-iron grating is placed over the unoccupied portion of the upper end of the shaft so as to prevent accidents.

On completion of the tunnel a standard conduit is installed in the horizontal portion and in each of the shafts, leaving a gap at the junction of the tunnel with the shafts to allow for proper training of the cables. This junction should be built with a curve having a radius of about 6 or 8 ft. to give proper working space and permit the cable to be installed with easy curves. The vertical conduit in the shafts can be built with single-duct vitrified tile, fiber pipe or stone conduit. Tee irons are fitted into the shafts at intervals of about 2 ft., so as to leave a clear space in the center of the shaft about 2 ft. wide. With the dimensions given for the shaft about 35 or 40 ducts can be installed between the tee irons and the shafts on each side.

A brick or concrete pier under the curve in the cables at the lower end of the shaft will support a considerable portion of the weight of the vertical cable. Some additional means of support for each cable should be installed at the top of the shaft. Care should be exercised to avoid clamping the cable too tight or placing too great a strain on lead sheath.

The telephone company in Chicago has used iron pipes exclusively for the vertical conduits in shafts, and has made the connections between these vertical pipes and the conduits in the tunnel with bends of 6 or 8-ft. radius in such a manner that the duct is continuous from the top of one shaft to the top of the other. Copper pull wires are installed at the time the conduit is built, so as to avoid difficulty which might be experienced with iron wires. It is thus practicable to pull in the cables at any future time without pumping out the tunnel, and at the same time eliminate all joints from the bottom of the shafts. It is probable that the same scheme could be used with smaller cables for electric light and power purposes, but this is not the practice.

A useful auxiliary in connection with such tunnels is a motor-driven pump of about 15-hp. capacity for removing the water from the tunnel. Such pumps can be obtained with either a direct-current or alternating-current motor, which can be readily lowered into the clear space in the tunnel. These outfits are built preferably with a vertical shaft, and for convenience in assembling are made in two parts.

The tunnel shaft should be erected from 25 to 50 ft. away from the river edge, depending upon local conditions. Where the river bank consists of made ground, it may be necessary to use a steel shield, extending into the impervious clay below the river. With a stiff clay the depth of the tunnel below the lowest portion of the river should be about 15 to 20 ft. If there is not sufficient depth of clay above the rock to give this amount of clearance to the river the tunnel should be built in the rock. In Chicago these tunnels are made at least 15 ft. below the surface of the rock, so as to avoid any danger of letting in water while blasting.

The cost of such a tunnel in clay will be about $25 to $35 per lin.ft., plus $50 to $60 per foot for the shaft. If built in rock the expense will be increased about 50%. These prices do not include manholes at the top of the shafts, or the conduits in the tunnel and shafts.

Very little water has been encountered in building tunnels in hard blue clay. Considerable water is usually present in building tunnels through rock, as the surrounding rock is somewhat shattered by the blasting, thus opening up water seams which add considerably to the difficulty of constructing the tunnel. When completed, tunnels through clay are generally dry while those through rock are somewhat leaky.

Slight leaks that do not interfere with construction work or prevent pumping the tunnel out for cable installations are not objectionable, as it is the practice to allow the tunnels to fill up with water after the cables are installed. Tunnels built in the manner described have been in service for about twelve years and no difficulty has been experienced in the operation of the cables contained therein.

*From a report of the Committee on Underground Construction, presented at the annual convention of the National Electric Light Association, in Chicago.

Strong Dredge Pins for holding together the bucket line on elevator dredges are of the utmost importance and are discussed in the "Engineering and Mining Journal" by Ralph A. Young, Chemist and Engineer of Tests, Marion Steam Shovel Co. The first pins with which Mr. Young is familiar were forged from steel of about 0.25 to 0.30% carbon, machined. These being very soft they soon wore out and had to be replaced. The next were made of openhearth steel of 0.40% to 0.45% carbon content, and these gave better service but were not trustworthy. Later, higher carbon steels were used, but at 0.90% the leaf of the pins began to break, while the cost also increased owing to the difficulty in machining. Manganese steel has not proved a satisfactory metal for dredge pins. It has a high coefficient of expansion and a very low heat conductivity. A dredge pin in use on one of the larger machines is 7 or 8 in. in diameter, and unless the manner and speed of heating, the temperature and the quenching are absolutely correct, internal checks develop. Manganese steel to be of any value must contain 12 to 13% manganese. In 1914 80% ferro-manganese sold at $36 per ton. At the present time it is quoted at $400 to $450. Mr. Young has endeavored to produce, in a measure, from carbon steel the same results that have been attained by use of alloys. First, a steel was chosen whose carbon content would with proper treatment produce a high degree of hardness, yet retain sufficient toughness to prevent breakage. It must also be of uniform composition, free from burnt oxides, incorporated slag and piping. When the billets from which the pins are to be forged reach the forge department, test drillings are taken, to check the mill. Test specimens are also cut from many of the billets, and these are prepared and examined under the microscope. The pins are sent next to the machine shop and thence to the bucket line. Following are a few results selected at random from a recently manufactured line of pins:

	1	2	3	4	5
Tensile strength, lb. per sq.in.	88,500	88,680	85,750	89,000	86,400
Elastic limit, lb. per sq.in.	55,700	54,100	53,400	58,250	52,610
Elongation in 2 in., %	23.5	28.0	24.5	21.5	23.6
Reduction in area, %	61.2	64.7	58.7	53.8	57.6

Hollow-Tile Sewers Built at Clinton, Iowa

Sewer districts Nos. 2 and 3 at Clinton, Iowa, now under construction, will serve all the territory known as the Hill District and also part of the business section of the city, a total area of about 352 acres. This southern part of the city has been very closely built up during the past 30 years, but owing to the large size of sewers required and the low valuation of the property, the city hitherto has been unable to finance the project. The system comprises 6.3 mi. of sewers ranging from

FIG. 1. SEGMENTAL BLOCK SEWER CONSTRUCTION AT CLINTON, IOWA

10 in. to 54 in. in diameter, with a 54-in. outfall in 5th St. and a 33-in. outfall in Franklin Ave., discharging into Beaver Slough.

Three interesting features of the work are the use of vitrified segmental sewer blocks, the large amount of rock excavation and three difficult crossings under the adjacent main tracks and yards of the Chicago & Northwestern Ry., the Chicago, Burlington & Quincy R.R. and the Chicago, Milwaukee & St. Paul Ry. Sewers 24 in. in diameter and larger are built of two-course vitrified segmental blocks, of the Ferguson type. An exception to this is the 33-in. double-strength vitrified pipe that was used in the Franklin Ave. outfall sewer. Sewers less than 24 in. in diameter are of vitrified-clay pipe. Manholes and catchbasins are of concrete.

In the segmental-block construction the blocks of the outer course are hollow, while those of the inner course are flat liner blocks having a smooth surface curved to the required diameter and two ribs on the back to key or interlock with the outer course. This construction is shown in Fig. 1. The blocks are laid up in 1:2 cement mortar, and the inner blocks are laid in a bed of this mortar, so as to make a water-tight and rigid structure. The chambers in the outer blocks serve to carry the drainage or seepage water during the construction, thus enabling the men to work in a trench practically dry.

A considerable amount of the trenching was rock, with a depth of 1 to 10 ft. and a cover of 2 to 9 ft., so that the maximum depth of trench to grade was about 19 ft. The rock excavation amounted to 9,000 cu.yd.

Backfilling from the spoil bank of soft material deposited by the excavator was done by means of a Waterloo backfiller. This machine consists of a gasoline hoist mounted on a truck and operating a cable attached to a scraper on the opposite side of the trench. The scraper is guided and pulled back by hand, two men being required to operate it. The hoist is on a revolving platform carried by the truck, so that it can operate the cable through a considerable angle and thus backfill a good length of trench from each position before being shifted. This hoist was used also to pull the trench sheeting. A fall was hooked to a tripod straddling the trench, with a grip at one end, while the other end was led to the niggerhead of the hoist.

The railway tracks and yards of the three railways were crossed at 5th St., 15th Ave. and Franklin Ave., the length of crossing being approximately 240 ft., 380 ft. and 200 ft. respectively. The first two were constructed with double-course vitrified segmental blocks and have interior diameters of 39 in. and 45 in. The third crossing was constructed with 33-in. double-strength vitrified sewer pipe. In all cases the blocks and pipe are surrounded with 4 in. of concrete, made with 1 part

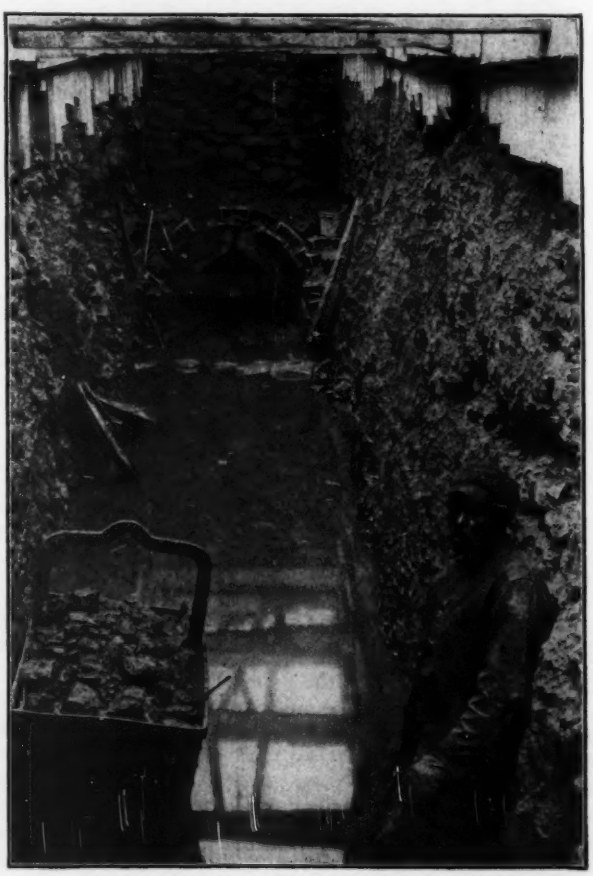


FIG. 2. TRENCH EXCAVATION IN ROCK FOR SEWERS AT CLINTON, IOWA

of cement to 6 parts of river gravel. The concrete was reinforced with a continuous sheet of American Steel and Wire Co.'s woven-wire netting with 4-in. triangular mesh. This was bent in oval form, being 1⅛ in. from the inner surface at the vertical diameter and 1½ in. from the outer surface at the horizontal diameter. This reinforcing sheet had 9-in. longitudinal lap joints in the upper quarter of the concrete ring.

The sewers were constructed under the railways in open cut, the tracks being supported on pile bents driven by a steam piledriver mounted on trucks. These bents were capped, and stringers were placed to carry the tracks. Owing to the large amount of traffic, no obstructions above the surface could be allowed.

The contract for this work was let Sept. 14, 1915, to Thomas Carey & Sons, of Clinton, Iowa. The contract prices for block sewer work were $8.15 per ft. for 54-in., $7.15 for 45- and 39-in., $6.15 for 36-in., $5.15 for 33-in. and $4.15 for 30-in. The cost was paid partly by special assessment to abutting property according to the benefits received. The balance was raised by bond issues supported by a district tax and a main sewer tax, as provided by the Iowa law. This sewer system for the two districts was designed by J. G. Thorne, City Engineer, and was constructed under his direction.

Waterproof Coal Pits and Fireproof Ashpits

In the concrete coal pits of railway coaling stations of the elevator type it is essential that the pit (fo. the elevator bucket) should be water-tight. The pit is usually considerably below the groundwater level and is subject to pressure, and when once put in operation it is a matter of difficulty and expense to get at it and make repairs.

A plan which has been used with success is to place within the concrete a steel boot or tank with joints soldered in the field. A 6-in. thickness of concrete is placed first, and then the steel boot is set in position and soldered. When this has been made water-tight it is lined with 6 in. of concrete. All attachments, bolts, ladders, etc., are set in this inner lining.

The drawing shows a pit having a boot 6 ft. 11 in. by 11 ft. 6 in. and with a height of 11 ft., its top being above groundwater level. It is made of No. 20 galvanized iron, and the expectation is that if the metal should rust in course of time it would still form a waterproof diaphragm by combination with the cement. The concrete is a 1 : 5 mix, made with gravel, and mixed moderately wet. The use of a similar boot composed of burlap and asphaltic composition has given fair success. To place a waterproof lining outside of the concrete would involve greater excavation and additional form work.

In concrete ashpits or clinker pits, where locomotives clean and draw their fires, the concrete frequently deteriorates under the action of the intense heat from the bed of clinkers. In time large pieces fall out of the walls and repairs are difficult to make and maintain. After some experimenting it has been found that a fire-resistive concrete can be made with gold-ore slag as the aggregate, and this has been used with entire success. The maintenance work is very small. The slag is obtained from smelters or refineries at Omaha and Denver, and costs only about 90c. per ton. It is screened to a size of 1½ in. for the concrete, and a 1 : 2 : 5 mix is employed, using portland cement, sand and slag.

A clinker pit made in this way is shown in Fig. 2. It is 100 ft. long, 5 ft. deep and 3 ft. 8 in. wide, with heavy side and end walls and 12-in. concrete base. An 18-in. cross-wall divides the pit into two sections, each of which has a 6-in. overflow for the water used in quenching the clinkers. There is also a 6-in. overflow pipe in the cross-wall. The corners of the walls are faced with steel angles 6x3½ in., and second-hand rails embedded in the floor protect the concrete from damage by the grab buckets used in removing the clinkers. These buckets are handled by locomotive cranes.

On each side wall is a continuous ¾-in. steel plate, 12 in. wide, bored to fit 1¼-in. U-bolts which are embedded in the concrete and spaced 2 ft. c. to c. The track rail is laid directly upon this plate and secured by clips and nuts on the bolts.

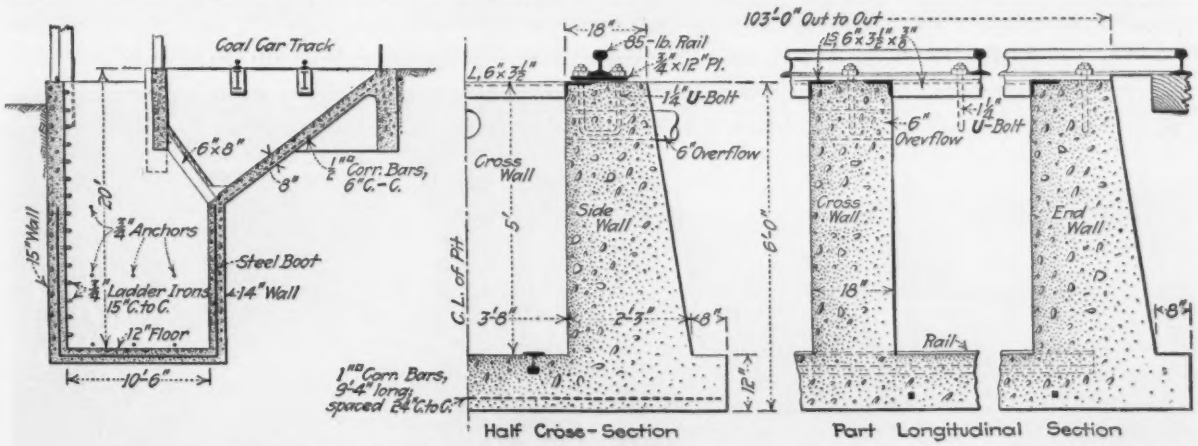


FIG. 1. CONCRETE COAL PIT WATER-PROOFED WITH STEEL BOOT

FIG. 2. CINDER PIT WITH FIRE-RESISTIVE CONCRETE MADE WITH GOLD-ORE SLAG

Motors for Electrified Lines in Southern France and to the Spanish frontier are being built in the American shops of the Westinghouse Electric and Manufacturing Co. They are 48 in number and will form the drive for eight 1,500-hp. Midi Ry. locomotives. They are being made here on account of the crowded condition of the French Westinghouse Co.'s shops. Single-phase current was first used on the Midi Ry. in 1903. 10 mi. of track near the Mediterranean coast being experimentally operated. In 1910 change of motive power on 70 mi. of main line and 105 mi. of branches was authorized. Large amounts of hydro-electric power are available.

New Methods and Progress on Twin Peaks Tunnel

By A. J. Cleary*

A general description of the Twin Peaks tunnel, the new highway on the line of Market St. in San Francisco, was published in *Engineering News* of Feb. 18, 1915. Since construction was started, on Nov. 30, 1914, the bore has been advanced from both ends an aggregate distance of 7,500 lin.ft. Eureka Valley station and 70% of Laguna Honda station have been completed, as well as the two shafts by which the tunnel will be ventilated. An outline of the construction procedure was contained in *Engineering News*, Nov. 4, 1915, p. 869. In the interim several new features in the method of handling the work have been introduced.

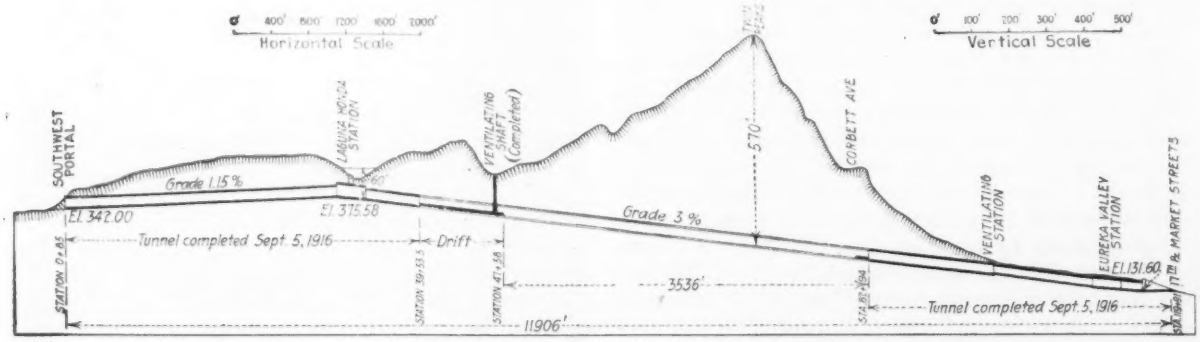


FIG. 1. PROFILE THROUGH TWIN PEAKS TUNNEL, SAN FRANCISCO, SHOWING PROGRESS TO DATE

Key and wall-plate pilot drifts with solid timbering are still excavated in advance of the main headings. Besides, from a point near the west portal a fourth drift had to be run at invert grade eastward along the center line, 600 ft. in advance of the heading to drain the wet, loose sand formation traversed west of Laguna Honda station. In both directions from this station, with a summit elevation of 375 ft., the tunnel slopes downward—toward the west on a 1.15% grade, and toward the east on a 3% grade.

FIG. 2. COMPLETED WEST PORTAL OF TWIN PEAKS TUNNEL

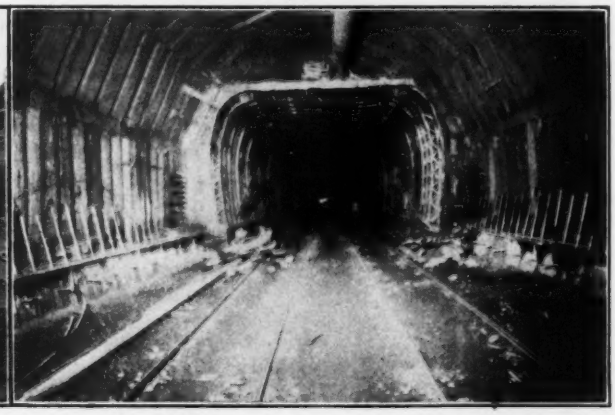


FIG. 3. INTERIOR OF TUNNEL, SHOWING FORMS AND TIMBERING

No unusual problem was presented in draining the 3,000 ft. extending from the west portal to Laguna Honda station, for the grade of the boring was up hill all through a sand formation in which comparatively little water was encountered. But in proceeding eastward from the station the direction of advance was on a 3% down slope through very wet, loose, clayey sand. When the heading was started eastward from Laguna Honda station it was found that 300,000 gal. of water daily drained into the face of the drift. The tunnel under these difficult conditions was advanced in the following manner:

New Method of Advancing Tunnel

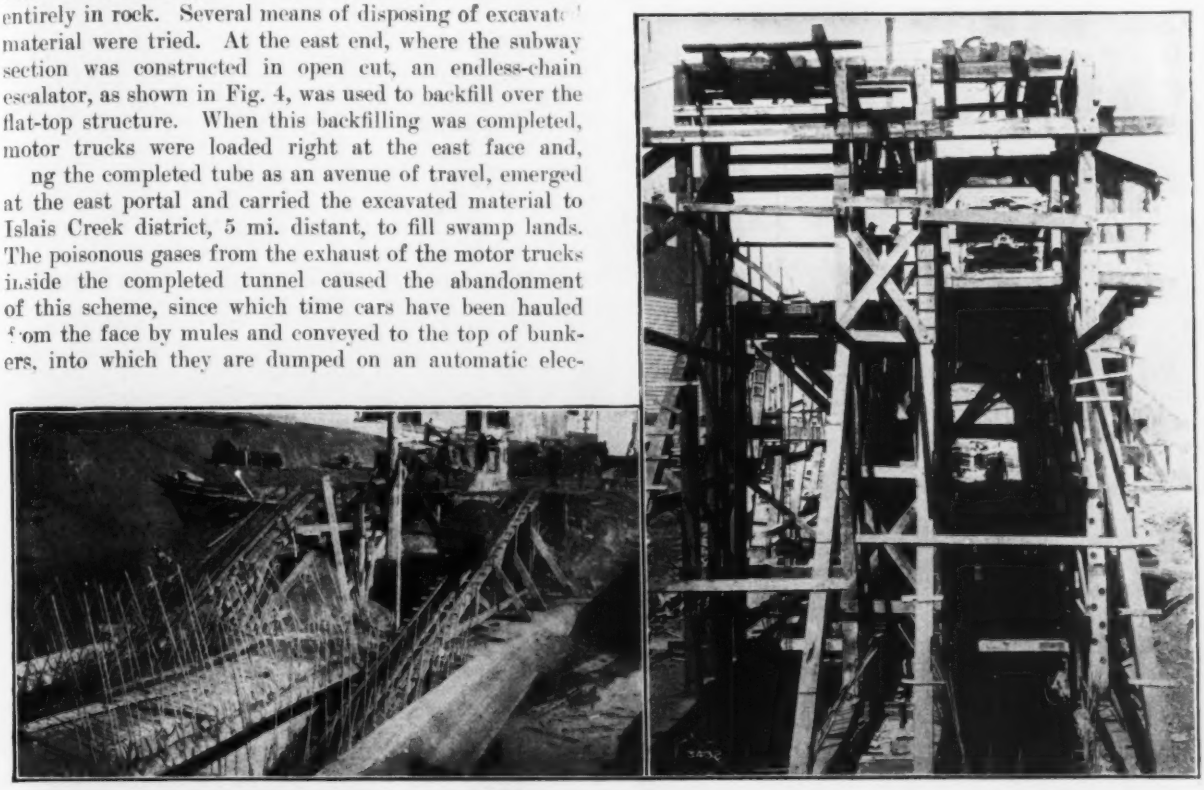
A pilot drift 5x7 ft. in section was started eastward from the station. As it proceeded, sumps were bored in its heading to which were led the suctions of three 3-in. centrifugal pumps. These served to keep the drift unwatered and also by continual operation lowered the water plane in the surrounding formation a depth of 60 ft., but working conditions were still extremely unfavorable. To afford more adequate drainage a second drift was started westward from the ventilating shaft located 1,300 ft. east of Laguna Honda station. The ventilating shaft finished will be 13 ft. in inside diameter, but excavation for it was made 20x32 ft. and 110 ft. deep, so as to include the full tunnel width and allow for timbering and forms. Timbering for the shaft consisted of vertical piles forming a solid sheeting and held in place by 12x12-in. bracing.

Several very treacherous deposits of quicksand were traversed by the latter drift as it was advanced easterly from the vent shaft. In one case it was necessary to bore an additional drift adjacent to the original one, in order to drain the formation. On July 20, 1916, the drift from Laguna Honda station reached the heading of the original drift from the ventilating shaft. The point of meeting was 420 ft. westerly from the shaft. The

*Assistant City Engineer, San Francisco, Calif.

through drift amply drains the formation traversed and makes possible rapid progress in the construction proper.

As the heading advanced from the easterly portal, very little except local pockets of water was encountered in the chert formation, and the tunnel excavation was almost entirely in rock. Several means of disposing of excavated material were tried. At the east end, where the subway section was constructed in open cut, an endless-chain escalator, as shown in Fig. 4, was used to backfill over the flat-top structure. When this backfilling was completed, motor trucks were loaded right at the east face and, using the completed tube as an avenue of travel, emerged at the east portal and carried the excavated material to Islais Creek district, 5 mi. distant, to fill swamp lands. The poisonous gases from the exhaust of the motor trucks inside the completed tunnel caused the abandonment of this scheme, since which time cars have been hauled from the face by mules and conveyed to the top of bunkers, into which they are dumped on an automatic electrically operated elevator situated in the slab opening originally occupied by the escalator.



FIGS. 4 AND 5. METHODS OF REMOVING SPOIL FROM TWIN PEAKS TUNNEL AT SAN FRANCISCO
Earlier escalator shown at left and later elevator at right

Concrete is now placed in the tunnel lining by the pneumatic process. Two plants have been installed, one near each portal. Specifications for concrete call for a consistency of 1 part cement to 2¼ of sand, with sufficient rock added so that the mortar fills the voids—approximately 5 parts. With every 100 lb. dry cement 8 lb. hydrated lime is mixed for waterproofing.

Special Pneumatic Delivery of Concrete

From the mixers on the surface, charges are dropped through a measuring hopper into the air chamber, whence it is forced into the forms through a pipe with spiral projections to give the mixture a rotary motion. At the west end, concrete has been conveyed pneumatically 2,500 ft. up a 1.15% grade, and it is anticipated that a distance of 3,000 ft. will be served up the 3% grade from the east mixing plant. The sequence of the concrete operations follows: (1) 100 ft. of footing poured on each side; (2) second and third days following, footing forms stripped, tracks laid for form tower and steel forms set; (3) 40 ft. of side walls and ceiling slab started the third day after initial pour; (4) while section of walls and ceiling are being poured, the remaining wall and ceiling forms are set, excavation finished and next forms set.

The arch was poured in long continuous sections, not being part of the regular schedule for pouring as outlined before. Excavation for the invert and the pouring of the concrete in the invert are postponed until the necessity of carrying muck and materials over a given stretch is relieved by the building of a new working inlet.

Both the design and the construction of Twin Peaks tunnel are under the direction of City Engineer M. M. O'Shaughnessy. L. T. McAfee is resident engineer for the city. Robert Storrie & Co. are the contractors.

Competent Engineers Essential to Road Construction—The main question that the people of the Union are immediately concerned with, is whether we shall get a dollar's result for every dollar we spend for roads. If, as the result of this Act, the people are induced fully to realize the necessity of placing skillful and experienced men in charge of road building and road maintenance, a great advance will have been made and the efforts of those who labored to secure the legislation will have been rewarded. I assume, as a matter of necessity, that this law will require the employment in every state of experts—of real experts. This word is very much misused and abused, as the word "theorist" is. I frequently hear a contrast drawn between the theorists and the practical men. There is no basis for it. The classification ought to be into good theorists and bad theorists, between practical men and unpractical men. A really good theorist is highly practical; and so is a real expert. The public is somewhat suspicious of experts, because, I think, so many people pose as experts who are not. I repeat that this Act will necesitate trained intelligence in the service of the state as well as in the service of the Federal Government. It requires the state to accept it. That, as I understand it, implies the assent of the state to every provision of the Act. One of these provisions is that projects, plans, specifications, and contracts shall be submitted for approval to the Department of Agriculture; and I have a suspicion that plans and specifications will not be approved unless they are submitted by people who know about such things.—From an address by Secretary Houston, of the Department of Agriculture, before the delegates of 37 states interested in Federal aid to state road construction.

Wind Cripples Bridge Portals and Lower Laterals*

By Clifford Older†

A destructive storm distorted a steel bridge over the Kankakee River, near the line between Kankakee and Iroquois Counties, Illinois, on Mar. 21, 1916. The bridge was left in such condition that the effect of the wind pressure could be traced plainly.

The bridge consists of two 185-ft. spans, with trusses 26 ft. high spaced 17 ft. 2 in. apart. It was built probably about 15 to 20 years ago.

As a result of the storm the trusses of the west span now lean decidedly toward the north (see Figs. 1 and 2). The east span was not so badly damaged, but it also has an inclination in the same direction.

Shearing Failure of the Portals

The top chords, though displaced laterally, were found to be in perfect alignment. The top lateral struts and diagonals were practically undamaged. The upper lateral system is light, and there is no sway bracing intermediate of the portals (Fig. 3); further, the top lateral struts were too shallow to transmit any of the top-chord wind load into the posts by portal action.

From the facts and the condition of the portals it is evident that the top lateral system served, as intended in the design, to carry the wind load to the portals. The portals, however, proved to be too weak to transmit it down the end posts to the foundation.

The portals of the west span and the west portal of the east span were distorted, with contraflexure near mid-length. The distortion occurred largely in the portion not affected by the kneebraces (Fig. 2). The lacing bars, which were flat bars with one rivet at each intersection, were buckled in the compression system, and some of the bars in the tension system were pulled in two.

It seems evident that a slightly greater wind load would have caused complete failure of the portals, resulting in tipping over of the trusses and complete collapse of the spans.

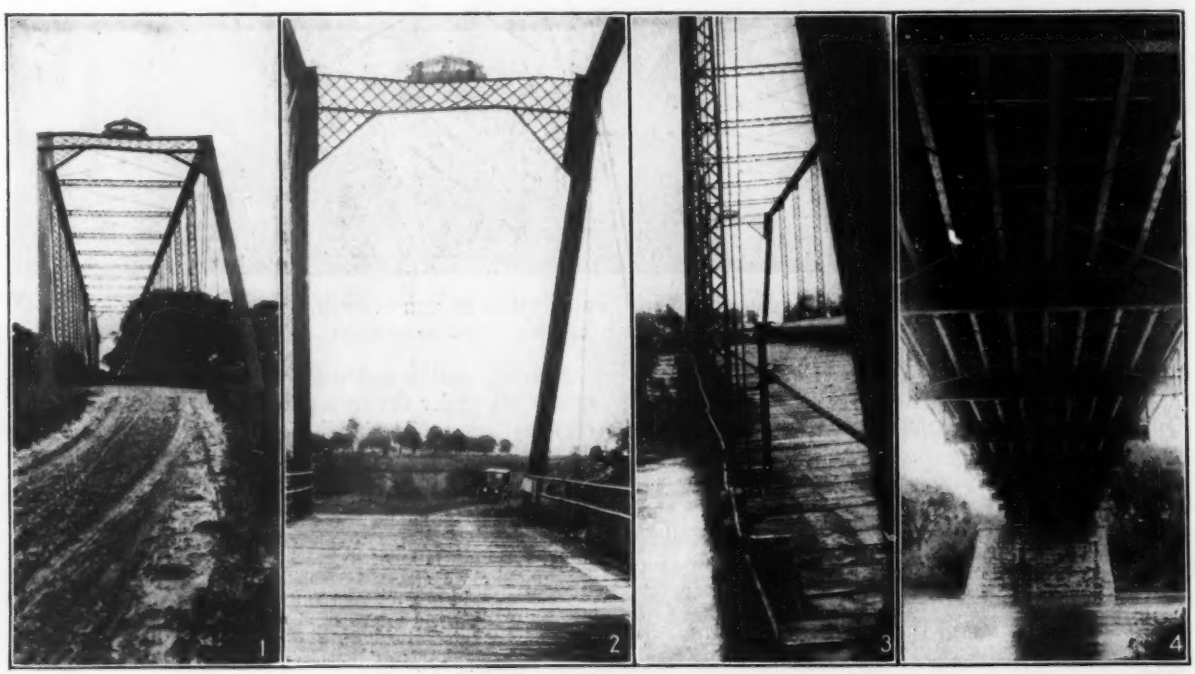
The original shop drawings do not give the name of the shop or the name of the designer. The portal is marked "Standard Portal No. 5," with the note, "2½x3x ¼-in. angles, rivets ⅝, open holes $\frac{13}{16}$."

Lower Chord Failed as Chord of Wind Truss

A partial failure of the lower lateral system of each span occurred also. In the case of the west span this was of such kind that failure was imminent here, as well as in the portals. Notice the curve of the stringer lines in Fig. 4.

The lower chords are eye-bars for the full length of the span. The lateral rods are round bars passed through holes near the ends of the floor-beams and bearing on bent plates riveted to the floor-beam webs on the far side. They did not fail, although the bent plates were somewhat distorted by the pressure of the nuts and the rods were probably somewhat overstressed. Some of the diagonals of the opposite inclination, however, showed signs of failure of the wind truss as a whole by being pushed through until the nut was an inch or more away from the bent plate (Fig. 5).

The partial failure of the lower lateral systems occurred because of reversal of the dead-load stress in the lower-chord bars on the windward side. The lower chords



FIGS. 1 TO 4. HOW THE KANKAKEE RIVER BRIDGE FAILED UNDER WIND PRESSURE

Fig. 1—From the west, showing west span leaning to north and both portals distorted. Fig. 2—Destruction of west portal of west span. Fig. 3—The buckled bottom-chord eye-bars on the south side of the west span. Fig. 4—Curved alignment of the stringers, showing the lateral failure

*Reprinted with slight condensation from an article in "Illinois Highways."

†Bridge Engineer, Illinois Highway Department, Springfield, Ill.

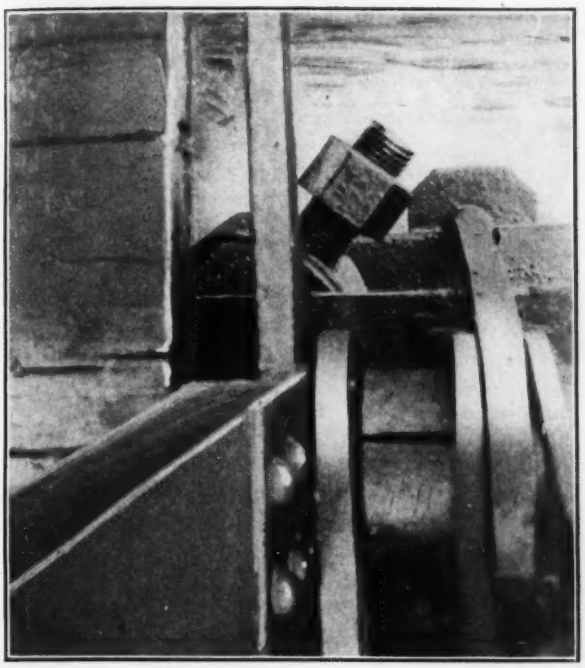


FIG. 5. VIEW DOWNWARD AT COUNTER ROD IN LOWER LATERAL SYSTEM, SHOWING NUT PUSHED AWAY

were found displaced laterally, but are in perfect alignment from the second panel point at one end to the second panel point at the opposite end of each truss.

Bridge Seats Displaced by the Pull

It is evident that the wind force brought to the shoes, in excess of that necessary to overcome the horizontal component of the dead-load thrust of the end posts, would have a tendency to pull the shoes off the foundations. That this excess load was considerable was indicated by the displacement of the stones on which the shoes rest at the pier. Movement of the upper ends of the end posts, as the portals yielded, no doubt aided the displacement of the stones. It is doubtful if much uplift occurred, because of the lack of sway bracing and the failure of the portals.

No hinged bolsters were provided, but rollers were in place under the pier shoes. This expansion device appears to have been sufficiently serviceable to have permitted a recovery movement of the lower end of the end posts when the wind load was released. This movement was limited, however, by the length of the slotted holes through which the anchor bolts passed.

The horizontal component of the dead-load stress in the end posts was not sufficient to push the shoes back to place after the wind subsided. Neglecting uplift, this would lead to the conclusion that the total wind force applied to the shoes during the storm must have been more than double the horizontal component of the dead-load stress in the end posts. It is difficult to determine just what wind load would produce such a force, owing to the complicated action of the lower lateral system after reversal of the dead-load stress in some panels of the lower chord. Approximate computations seem to indicate, however, that the wind pressure must have been in excess of 220 lb. per lin.ft. of lower chord.

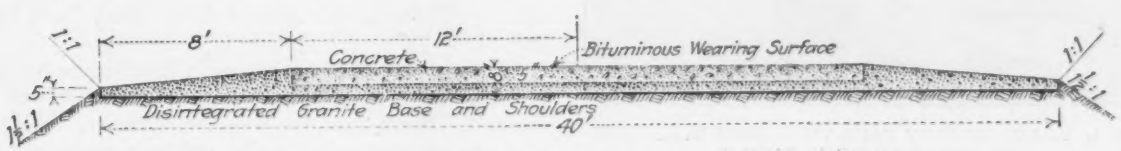
Special Concrete Pavement for Motor Trucks; Los Angeles

The County of Los Angeles, Calif., is constructing a concrete pavement of special design for the use of motor trucks between the harbor of the City of Los Angeles at San Pedro and the business district of the city. The total length of this route from Alameda and Slauson St. in the City of Los Angeles to the northwest boundary of Wilmington, which is a portion of the City of Los Angeles, is 13.3 mi.

The concrete base for this road will be 24 ft. in width and 8 in. thick. It is made of 1:2:4 concrete. This base will rest on a cushion of decomposed granite 5 in. thick and 40 ft. in width. Shoulders 8 ft. wide will be built of decomposed granite on each side of the concrete base. The standard section for most of the Los Angeles County highways is a concrete base 20 ft. in width and, 5 in. in thickness, with 5-ft. shoulders. Transverse expansion joints across the full width of the concrete will be placed at 25-ft. intervals.

On the concrete is to be a bituminous carpet of a character common in California roadwork. The specification for the surfacing is worded as follows:

> After the concrete pavement has been constructed, all dust, mud, earth or foreign material of any kind which may have accumulated upon it shall be removed and the surface flushed with water. When it has become sufficiently hard and dry and in the opinion of the Road Commisioner is ready to receive it, asphaltic oil shall be applied in one application of approximately ½ gal. to the square yard.
>
> Directly after the oil has been applied, stone screenings or sand shall be uniformly spread upon it in sufficient quantity to combine with the oil without leaving any excess screenings or sand on the finished road surface. The stone screenings or sand are to be spread in a direction parallel with the road and never crosswise. If necessary, from time to time, additional screenings or sand shall be spread, as the Road Commissioner may direct, to cover any oil which may come to the surface, until the final completion and acceptance of the work.



CROSS-SECTION OF SPECIAL CONCRETE PAVEMENT; ALAMEDA ST., LOS ANGELES

It is estimated that this road will cost approximately $26,000 per mi. The County of Los Angeles is furnishing all material used in its construction.

Test for Corrosion Resistance with Aerated Water—By circulating heated and aërated water from a small storage tank at fairly rapid rate through coils of pipe made up of alternate lengths of different kinds of pipe, F. N. Speller, of the National Tube Co., has been able to get in a short time comparisons of the corrosion resistance of the several kinds of pipe used. A test of three months, he states, gives about as much corrosion as two years of normal service in a hot-water line. An air ejector is used to aërate and circulate the water. The ejector, with pump, a thermostat-controlled gas heater, and the tank and coil of pipe make up the whole device. The air is first filtered through excelsior to remove oil.

Types of Dump-Cars Used On Construction Work--II

SYNOPSIS—The first part of this description of various types of dump-cars used on contract and other construction work was published in "Engineering News," Sept. 28, 1916, and dealt with various styles of cars of 1-yd. to 30-yd. carrying capacity. The present article describes other types of cars with capacities ranging from 18 yd. to 40 yd. and also includes the use of unloader plows for dumping material from flat-cars and gondola cars.

The dump-cars described in the former article are all of the tilting type, and one special class of cars of this type remains to be dealt with, before taking up the non-tilting type of car.

Sectional Tilting Cars

Sectional tilting cars are unusual, although several varieties of them have been built. The car has three or more rectangular boxes (sometimes V-shaped hoppers) mounted on the underframe and so arranged as to dump independently and to either side. In this way material may be discharged in small lots at different points, or different materials, as sand and stone for concrete, may be carried on one car. These cars have been used also for handling concrete. In one design the boxes are set much lower than usual, convenient for hand loading, and have a lateral travel to one side before tilting, so as to deliver the load clear of the track.

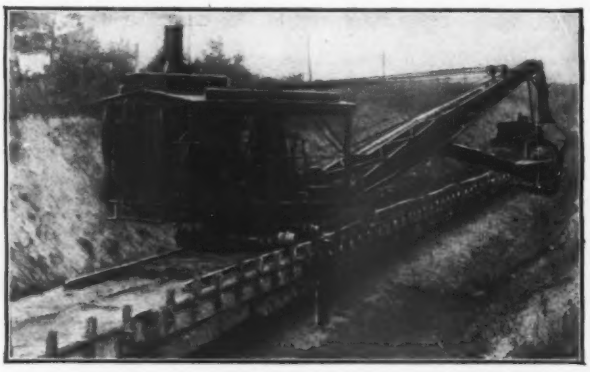


FIG. 1. TRAIN OF FLAT-CARS WITH SIDE BOARDS TO INCREASE THEIR CAPACITY

Several street railways have used construction cars of this general type, but of two different classes. One class has separate boxes or bodies, as just described; the other has a single body, but divided by transverse partitions into separate compartments each having its own doors. A train of 18-yd. cars of this class (motor car and trailers) is shown in Fig. 2, operating on the Cleveland Electric Ry., Cleveland, Ohio. These cars were built by the Differential Car Co., of Nashville, Tenn. With such cars different materials can be carried in one load, or with the load level full, not heaped up, the contents of the compartments can be delivered at different points along the line.

Flat-Cars and Unloader Plows

While the flat-car does not dump its load, but requires a plow for power unloading, it is employed so extensively in handling material on construction and maintenance work that it must properly be included here. In railway service the use of flat-cars in connection with unloader plows is general for handling excavated material, both on construction work and in such maintenance work as ditching and widening cuts, also to some extent for ballasting track. One reason for this is that the cars are part of the regular equipment of the road. They are suitable for miscellaneous work when it is not practicable or economical to invest in special equipment, and they can be adapted either to work-train or freight-train service, as may be required. The question of the factors affecting the selection of the type of car for any particular work was discussed editorially in *Engineering News*, Sept. 28, 1916.

The cars are liable to damage from rough treatment, but repairs are likely to be simple and cheap, due to the use of standard parts. Much work has been done well and at low cost with flat-cars, especially where the addition of sideboards has enabled fairly heavy loads to be carried.

Flat-cars may be of advantage in handling heavy rock, stumps, logs or other material that cannot well be dumped. Some railways consider, however, that such cars are not economical under ordinary conditions and

FIG. 2. SECTIONAL DUMP-CARS ON ELECTRIC RAILWAY AT CLEVELAND, OHIO
Differential Car Co., Nashville, Tenn., builder

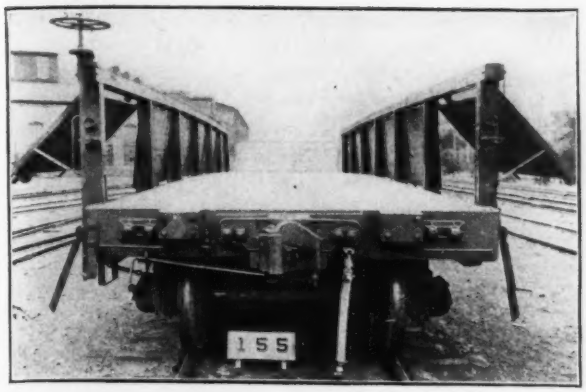


FIG. 3. SIDE-DOOR GONDOLA CAR WITH TWO DOORS IN POSITION FOR UNLOADING

that on account of the relatively small amount of material that can be loaded on a flat-car it is better to have dump-cars and to leave the flat-cars for revenue freight service.

On some of the work in the Culebra Cut of the Panama Canal the excavation came out in such large blocks that handling by flat-cars was about the only practicable method. The cars for this work had one solid side and one open side, with the floor extended about 12 in. on this latter side. They were unloaded by a side plow that would throw off the rocks whatever their size. With these cars heavily loaded and the material piled against the fixed side, the center of gravity was thrown to one side of the center line of the car. This caused severe wear of the rail head and high cost of track maintenance, especially on curves.

Only a limited yardage per car can be loaded unless side boards are used. These may be loose boards held by stakes in the car pockets, or they may be permanently attached by hinges or short chains, so as to fall down against the sills when lowered. Aprons cover the spaces between the cars, so that the material being unloaded will not fall through upon the track, and they also carry the plow across these openings. Fig. 1 shows a train of flat-cars in railway ditching work, with loose side boards attached by chains and held in place by stakes. The ditching machine travels along the train, and the boards are placed as the cars are loaded.

With the old style of blunt plow this method of unloading material was rather slow. With the more modern plow of smaller angle and greater length this objection does not apply, as the material does not pile up upon the plow and the pressure of the material against the sides of the car is not nearly so great. In this way there is less obstruction to the movement of the plow, with consequent higher speed and less damage to the cars. In operating on curves the cable must be led through snatch blocks hitched to the car, and there is liability of additional damage due to the strains on stakes and stake pockets.

Unloading material in this way has the advantage that it can be distributed in quantity as desired by stopping or moving the train while unloading. The use of plows in connection with gondola cars is discussed later. The field for flat-cars is where the material is to be handled over existing standard-gage tracks, particularly where it is necessary to load by hand.

Side-Door Gondola Cars

These cars, like flat-cars, do not dump the load, but require shoveling or plowing. They are similar to ordinary open freight-cars, but the sides instead of being fixed are formed by swinging panels. They may have low sides hinged at the bottom, but generally the sides are higher and hinged to a top rail. Latches hold the doors closed. Movable ends or end gates are fitted.

Fig. 5 shows a large car of this type for track elevation and other work on the Chicago & Western Indiana R.R.

FIG. 4. DROP-BOTTOM GONDOLA CAR FOR SIDE DUMPING
Ralston Steel Co., Columbus, Ohio, builder

The cars are 40 ft. long, with a carrying capacity of 50 tons and a light weight of 19 tons. They were built by the Haskell & Barker Car Co., of Michigan City, Ind. The top rail of the side frame is carried on heavy stakes, and to this the side panels or doors are attached by strap hinges. A locking bar extending along the sill has lugs that bear against the doors to hold them closed, and this

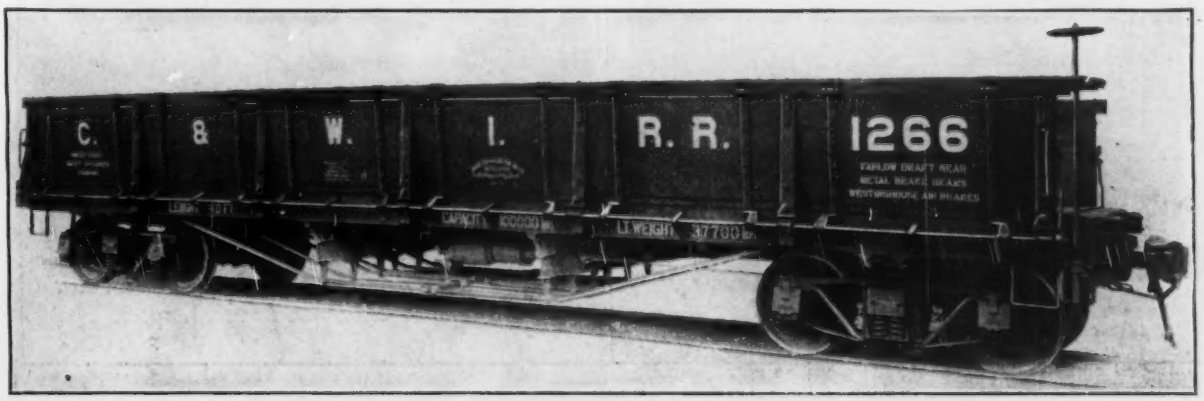


FIG. 5. SIDE-DOOR GONDOLA CAR FOR USE WITH UNLOADER PLOW
Haskell & Barker Car Co., Michigan City, Ind., builder

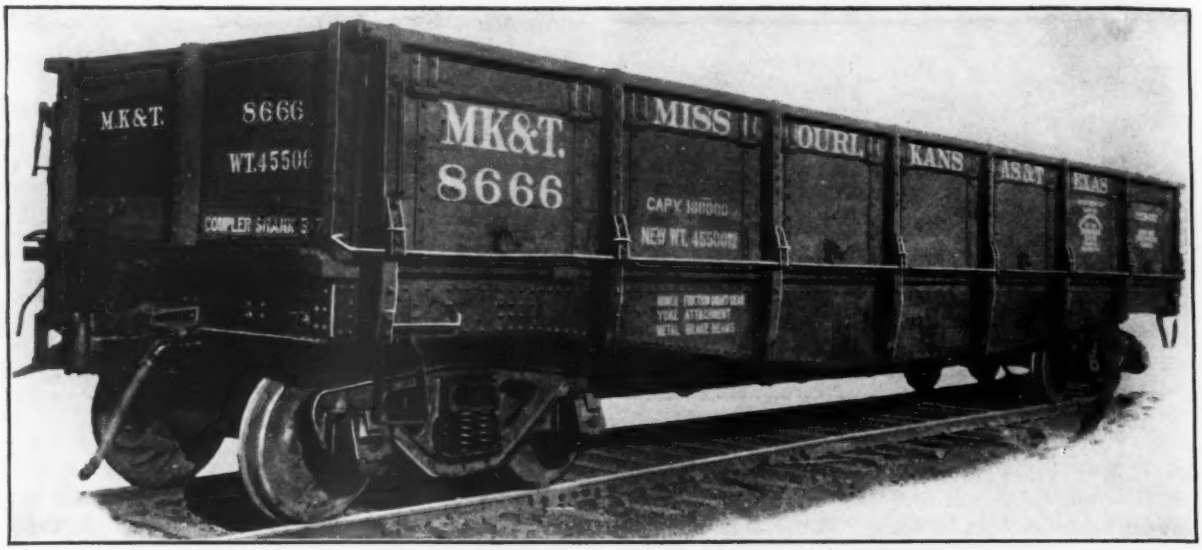


FIG. 6. CENTER-DUMP CAR FOR BALLASTING (CONVERTIBLE INTO SIDE-DOOR GONDOLA CAR FOR UNLOADING WITH PLOW)
Rodger Ballast Car Co., Chicago, builder

rod is operated by end levers to lock or release the doors. Fig. 3 is an interior view of the car, showing the doors unlatched and the two doors at the end propped open in the position they occupy when material is being plowed out. At the far end of the car is shown the steel apron to cover the opening between cars and prevent material from falling on the rails.

The gondola car will hold 20 to 40 cu.yd., as against 8 to 12 yd. (or 12 to 15 yd. with side boards) on a flat-car 32x8½ ft. But the doors cause slower unloading by means of the plow, and unloading by hand is slow and expensive. However, in some cases, as on track elevation, a large gang of men unloads the cars and then distributes the material and raises tracks until the next train arrives.

If the contents are to be plowed out, the end gates are removed from the cars before loading, and the spaces between the cars are covered by steel aprons. For unloading by hand, the end gates may be left in place, in which

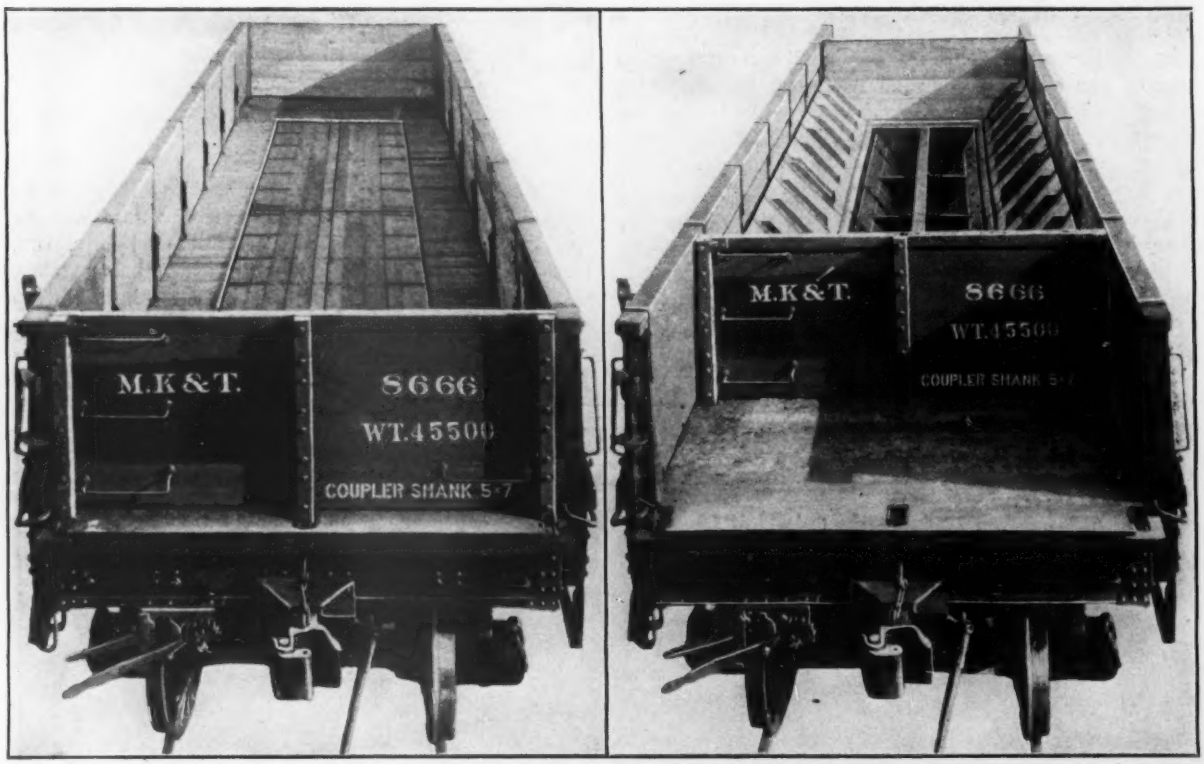


FIG. 7. CONVERTIBLE CENTER-DUMP AND SIDE-DUMP CAR
The right view shows the interior of the car arranged for ballasting, with sloping floor and longitudinal hopper. The left view shows hopper covered and car suitable for general transportation. With ends removed the contents may be plowed out through side doors

case larger loads can be carried. While some engineers of wide experience consider that these cars give economical service with the use of unloader plows, others believe them economical only for such light materials as sand and cinders and not for heavy plowing. It has been suggested, however, that unfavorable opinions are based probably on efficient handling or experience with the older style of equipment, as with modern equipment properly handled the plow is a quick and effective means of unloading.

The cars are favored more by railways than by contractors and have the advantage that when not required in work-train service they can be put to regular freight service. Their special advantage is where large quantities

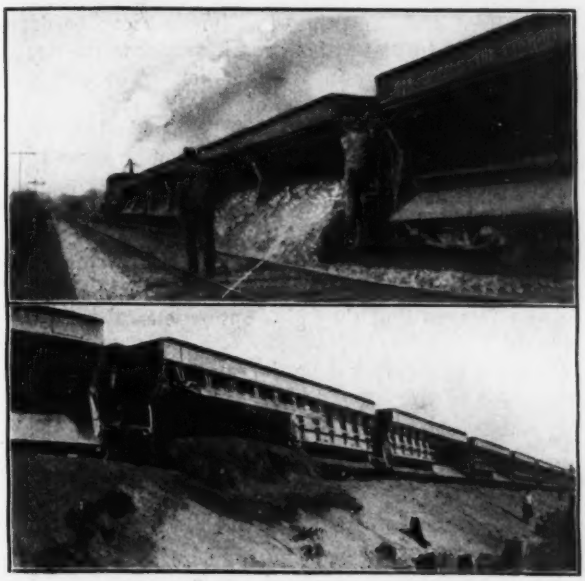


FIG. 8. TRAINS OF 30-YD. STEEL HOPPER CARS PLACING BALLAST AND WIDENING FILL
Goodwin Car Co., New York, builder

of material are to be handled on main line and for considerable distances; when running, they have more stability than dump-cars. They have been employed extensively on filling for track elevation and for filling trestles or bridges. For distributing ballast they have been used in a limited way, but center-dump cars are generally preferred for this work.

Drop-Bottom Gondola Cars

These are flat-bottom cars with closed ends and fixed sides, having the bottom composed of panels hinged against the center sill and dropping toward the side to an angle of nearly 45°. Usually half the doors on each side are operated independently, making four sections. The cars are seen largely in revenue service for hauling coal and in work-train service for filling trestles. They are usually too heavy for temporary trestles in making new fills.

A car of this type built by the Ralston Steel Car Co., of Columbus, Ohio, is illustrated in Fig. 4. The doors are raised and lowered by a cranked operating rod carried in bearings beneath the ends of the transoms of the main frame. This view shows all the doors on one side lowered, but half the doors on each side can be operated independently of the others. The Ralston car was described in *Engineering News*, Mar. 30, 1916.

The cars are specially suitable for dumping through the open floors of trestles and track hoppers. On solid track, however, much of the material rolls back on the rails and must be removed before the car can proceed. Hand shoveling in this way is slow and troublesome. Sometimes a tie is chained across the rear truck to act as a plow in clearing the rails. This is objectionable practice, as the heavy loads will skid the wheels and cause flat spots, while the tie is likely to get blocked and cause derailment. Some material also will fall through the spaces between the opened doors and thus drop upon the rails. These cars are rarely found in connection with steam-shovel work.

As practically the entire bottom drops, the cars are self-cleaning. If used for widening a bank on one side, however, only half the drop-floor can be operated, and shoveling is necessary to empty the car. The operation of the dumping levers is not always convenient or safe on trestles, but in some such cases the lever has been worked from the ground by means of a long rope. The doors being operated in four groups, the load can be distributed along the track or at different points, which may be desirable in ballasting. The cars must be substantially built, or after a little rough usage the doors will not close properly.

Center-Dump Car

Equipment of this class includes gondola cars with a longitudinal V-shaped hopper beneath the floor, the lower part of this being formed by doors hinged at the upper side. The hopper may be in the center of a flat floor, or

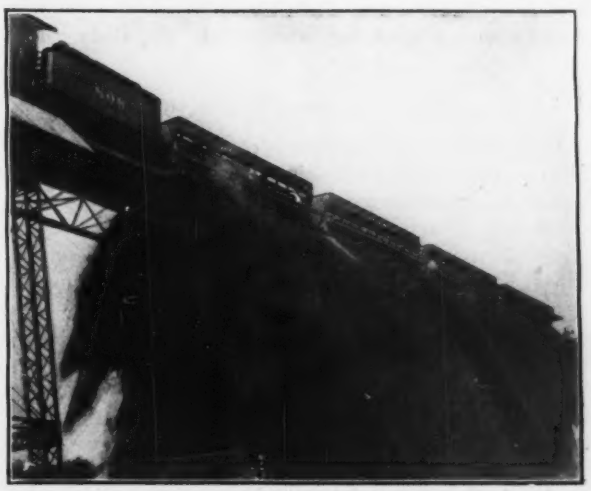


FIG. 9. FILLING STEEL TRESTLE FROM 30-YD. CARS WITH TRAIN IN MOTION

it may extend to the vertical sides of the car. In the former case, for a convertible car, hinged panels extend the slope from the top of the hopper to the sides.

As dump-cars they are used mainly and very extensively for ballasting. The material can be discharged while the train is moving, the amount being regulated by the width of dump opening and the speed of the train. A plow under the rear car levels the material and throws it clear of the rails. Care must be taken not to open the doors too wide or too rapidly, as the rush of material may cover the track and cause stalling or derailment of the train. Such cars may be so built as to be available for hauling grading material and filling.

The Hart convertible car of this type, Figs. 6 and 7, can be operated as a center-dump car, a side-dump gondola for use with an unloader plow, or as an ordinary gondola car in freight service. This car has a flat floor, with a longitudinal hopper, and movable panels extending the slope of the hopper to the vertical sides of the car. These panels are hinged at the edges of the hopper and can be folded down so as to cover it and make a flat floor. The vertical sides may also be composed of panels hinged at the top so that the car may serve as a side-dump gondola for making fills, widening banks, etc. With this last arrangement the car may be unloaded by hand shoveling, or the ends may be removed to permit the use of an unloader plow. This car, therefore, can be utilized for handling and depositing excavated material, distributing ballast and carrying revenue freight.

Fig. 6 shows a steel-frame Hart car of 50-ton capacity and a light weight of 23 tons, as used on the Missouri, Kansas & Texas Ry. for ballasting and filling. The longitudinal central hopper may be seen behind the deep girder sill, and the sides are formed by doors hinged at the top, as in the side-door gondolas already described. Fig. 7 shows the car arranged for two kinds of work. At the left is the position for ballasting, with the central hopper uncovered and its slope extended to the sides by the hinged floor panels. The end gates are set back to the hopper, which of course is only between the trucks. At the right is the position for ordinary freight service, with the panels folded down to form a solid floor and the end gates shifted out to the end sills. For use with an unloader plow, the solid floor remains and the end gates are removed, while hinged steel aprons cover the openings between cars. These cars are built by the Rodger Ballast Car Co., of Chicago.

Side-Dump Car with Inclined Floor

In this type of car the floor is of A-shape, sloping down from a center ridge to the sides, which are hinged at the top so as to swing outward. These cars are not used extensively in construction work. They have been employed to a limited extent in distributing small lots of ballast locally, also for dumping material for shouldering permanent track or raising such track to a new grade. An objection is that they deposit the material too near the track. They are apt to be rather top heavy for filling trestles, and some engineers consider them uneconomical for widening banks. Further, the load is likely to damage the doors as it escapes, causing high repair cost.

The principal field for cars of this type is in railway service, for handling ashes from locomotive terminals and removing refuse from yards and busy freight stations. For this work they may be small cars on four wheels or larger cars on trucks. They must dump on both sides, unless hand shoveling is resorted to, though a few special cars have been built with the floor sloping from the top of one side to the bottom of the opposite side.

Combined Center- and Side-Dump Car

A special type of large car for a great variety of purposes is the Goodwin dump-car. This has a fixed steel body of hopper shape, provided with bottom doors and aprons for regulating the discharge, and so arranged that the car can empty its contents on either side or both sides of the track (outside the rails), or on the inside of one or both rails, or partly outside and partly inside the track. For the side discharge the flow of material can be restricted, or the entire side of the car can be swung out to give full and unrestricted dumping. The lower parts of the sides are hinged at the upper edge and are normally inclined inward to form a V-shaped hopper. Their position is regulated by means of chains attached to the sides and led to the piston rods of horizontal air cylinders placed across the top of the car.

The Goodwin cars are built entirely of steel, and their capacity is 30 yd. level full or 40 yd. with heaped load. The dumping is effected by hand or by air and can be done for the cars separately or for the entire train simultaneously. The inclined aprons throw the material clear of the track, and the slope of the sides is such as to make the cars self-clearing even with sticky material. As the body is fixed and nontilting, the dumping can be done on bridges and trestles without causing shock to the structure, even whenthe train is in motion. The cars are built by the Goodwin Car Co., of New York.

Cars of this kind are shown in Figs. 8 and 9. The upper view in Fig. 8 shows a train in motion depositing stone ballast. The car at the right is delivering the ballast inside the rail. The next car, on which the operator is riding, is delivering outside the rail, the flow being controlled by the operator. The lower view shows a train making a fill, the sides of the cars being released and hanging free, so that they give unrestricted flow to the contents.

On much of the work done the cars are unloaded while the train is moving at 10 to 20 mi. per hr. In this way the filling or placing of material progresses rapidly and the work trains can be operated on main track with a minimum of interference with regular traffic. Fig. 9 shows the filling of a steel viaduct by means of these cars, with the train in motion.

The cars can handle rock and boulders as well as loose material, and in industrial service they are employed for transporting such articles as pig iron, billets, rail ends, scrap, etc. They are used extensively both by contractors and railways for grading, making and widening fills, distributing ballast, filling trestles or old bridges and for hauling stone, sand or gravel.

Dredging for Coal in the rivers of Pennsylvania is an industry by which, it is estimated, about 250,000 tons are annually recovered. The method of dredging is described by Howard I. Moses in the June issue of the "Journal" of the Engineers' Society of Pennsylvania. The anthracite-coal district of Pennsylvania is found principally in Lackawanna, Luzerne, Carbon, Schuylkill and Northumberland Counties, and over 80,000,000 tons of coal is mined yearly. Nearly one-half of this coal is prepared by the "wet process," requiring the use of vast quantities of water which, when wasted, carries in suspension millions of tons of fine culm, by which name is designated the fine coal that passes through the smallest screen in a dry-process breaker. Much of this finds its way into the principal rivers draining the anthracite district—the Lackawanna, the Susquehanna and its north branch, the Schuylkill and the Lehigh. They carry culm waste for many miles downstream, depositing it in shallows and eddies, back of dams and over valley bottoms. There are two principal types of dredges in use for recovering the coal—the suction dredge and the bucket dredge. The former is used exclusively at Harrisburg, while the other type is more favored elsewhere. The season averages eight months, and the total output of a dredge ranges from 8,000 to 10,000 tons. The dredging machinery is generally mounted in a stern-paddlewheel flat-bottom boat of 15-in. draft. The coal is discharged into flatboats or scows having a capacity of 12 to 14 tons. In and about Harrisburg, river coal—steaming sizes—sells from $1.10 to $1.50 per ton delivered, and f.o.b. flats at river's edge from 70 to 90c. per ton. Compared with similar sizes of run-of-mine anthracite at the prevailing prices, these show a considerable saving.

City Replanning in Duluth

By W. B. Patten*

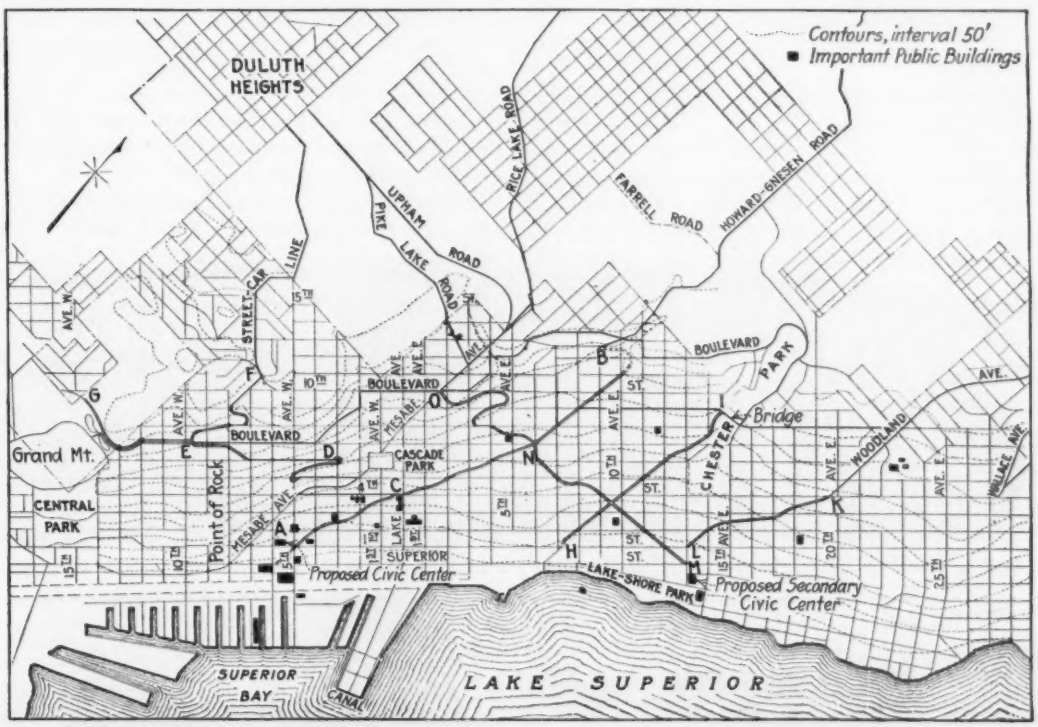
The central portion of Duluth, Minn., is an example of city planning without regard to topography, symmetrical growth, transportation or intercommunication. Although occupying a hillside rising rapidly from the shores of the Lake and Bay of Superior, the highways, with two exceptions, were designed on the gridiron system (see accompanying map). The streets, 300 ft. apart, running approximately parallel with the shore line and contours, have light grades throughout their length, except where they cross the so-called Point of Rocks, which separates the main business and residence sections from the West End. The avenues, 400 ft. apart, being at right angles with the streets, are generally normal to the contours. One exception to the rectangular system is Mesaba Ave., which skirts the easterly side of the Point of Rocks and which has been improved to the top of the hill, about 500 ft. above the main business street, but it is poorly located and has long stretches of grades running from 9 to 12½%. The other diagonal thoroughfare was called Washington Ave. and was about 1⅓ mi. east of Mesaba Ave. This avenue, except for one block, was vacated in the early history of the city.

Acting as a member of the City Planning Committee of the Duluth Commercial Club, the writer, who was formerly city engineer of Duluth, has planned several diagonal arterial highways leading up the hill by easy grades from proposed main and secondary civic centers near the waterfront.

The new layout is shown on the accompanying map. The main thoroughfare extends diagonally from Superior St., through the civic center *A* to a connection at *B*, with a rural highway leading northerly, and with The Boulevard, which is a driveway constructed along the old lake beach 475 ft. above the present lake level.

From the intersection of this arterial highway with Fourth St., at *C*, using platted streets where possible, and condemning across property where necessary, a route is shown passing through points marked *D*, *E*, *F*, *G*, which opens up the thinly populated districts near the center of the city.

The highway from *H* to *I* is a relocation of Washington Ave., formerly vacated; and that from *K* to *L* is an extension to First St. of Woodland Ave., the present terminus of which is at Fourth St. At *M* is a secondary civic center with two large auditoriums frequently used for public assemblages. It is proposed to open a diagonal highway from this point to an intersection with the one first described at *N* and with an extension westerly to a connection at *O* with Mesaba Ave. above its steep grades, and below its junction with several rural highways, which are heavily traveled, and at its intersection with The Boulevard.



PROPOSED ARTERIAL HIGHWAYS AND CIVIC CENTERS FOR DULUTH, MINN.

The projected civic center, hotels, freight and passenger depots and docks, and the main wholesale district lie on the lower levels of the city and just east of the Point of Rocks, the office buildings and retail trade adjoining to the east. The residential sections are north and east of the business zone.

The steepest part of the hillside is in the immediate vicinity of the civic center, the rise being over 500 ft. in less than 3,000 ft. The growth of population has been toward the east and, except along street-railway lines that have been found feasible, with decreasing density as the hill is ascended. There are thus, within very short distances horizontally of the business center, large tracts of

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land that are almost unpopulated. A small part of this territory is given the limited service of an elevated incline passenger railway, which operates in connection with a surface railway running to a settlement back of the crest of the hill.

The local street-railway company refuses to operate on grades of over 7½%. Consequently, its service is not extensive and above Superior St. is confined to those streets that can be reached by selecting avenues which are within the maximum grade limit. This leads to a duplication of lines on portions of some streets and roundabout routes with frequent right-angle turns. Thus, the West Fourth St. line in running from 5th Ave. West and Superior St. to its terminus, which is less than 1,500 ft. distant horizontally, travels 10,800 ft. and turns four square corners; and of this distance over 6,000 ft. is over streets on which other lines are compelled to run and which, owing to its proximity to the center of the city, is also a minimum-revenue territory.

To overcome the present difficulties and to avoid the inconveniences and congestion of traffic which will come in the future, following the large increase in population which is confidently expected, the writer has suggested the establishing of the several arterial highways shown on the accompanying plat and just explained in detail.

Relining a Leaky Reservoir at Omaha, Neb.

Basins 1 and 2 of the Walnut Hill reservoir for the Metropolitan Water District of Omaha, Neb., were built some years ago by throwing up earth embankments surrounding roughly square basins and lining the bottom and the inside slopes with a 6-in. thickness of plain concrete. Some time ago this concrete lining began to crack badly (see Fig. 3) and although the destination of the leakage was not evident, the presence of nearby houses and the possibility of the loss of the embankment led the engineers to reline both basins with an additional 4 in. of reinforced concrete laid directly on the old lining.

The new lining consisted of 4 in. of 1 : 2¼ : 4½ concrete reinforced in both directions with ⅜-in. square twisted rods spaced 7 in. c. to c. No expansion joints were provided in the whole new lining. The reinforcement was laid on the old concrete, as shown in Fig. 1, over the whole area before any of the new concrete was placed, the rods being tied and held the proper distance from the old lining with special clips.

The concreting was carried out with the special mixing and placing outfit shown in Fig. 2, which had been de-

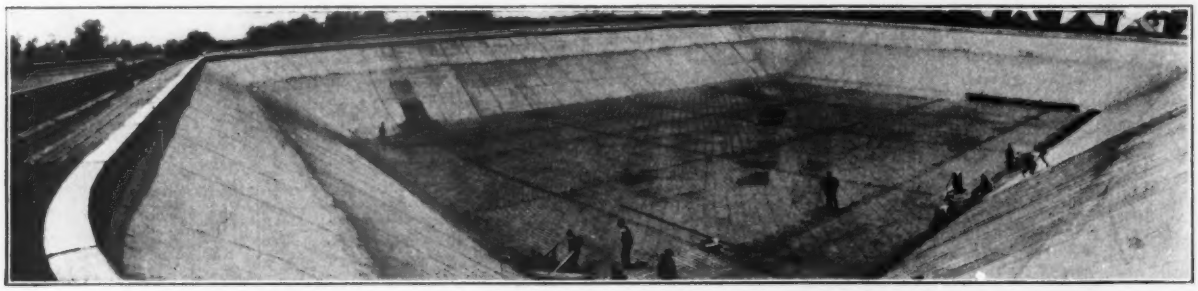


FIG. 1. BASIN NO. 1 OF WALNUT HILL RESERVOIR, OMAHA, WITH REINFORCING RODS IN PLACE

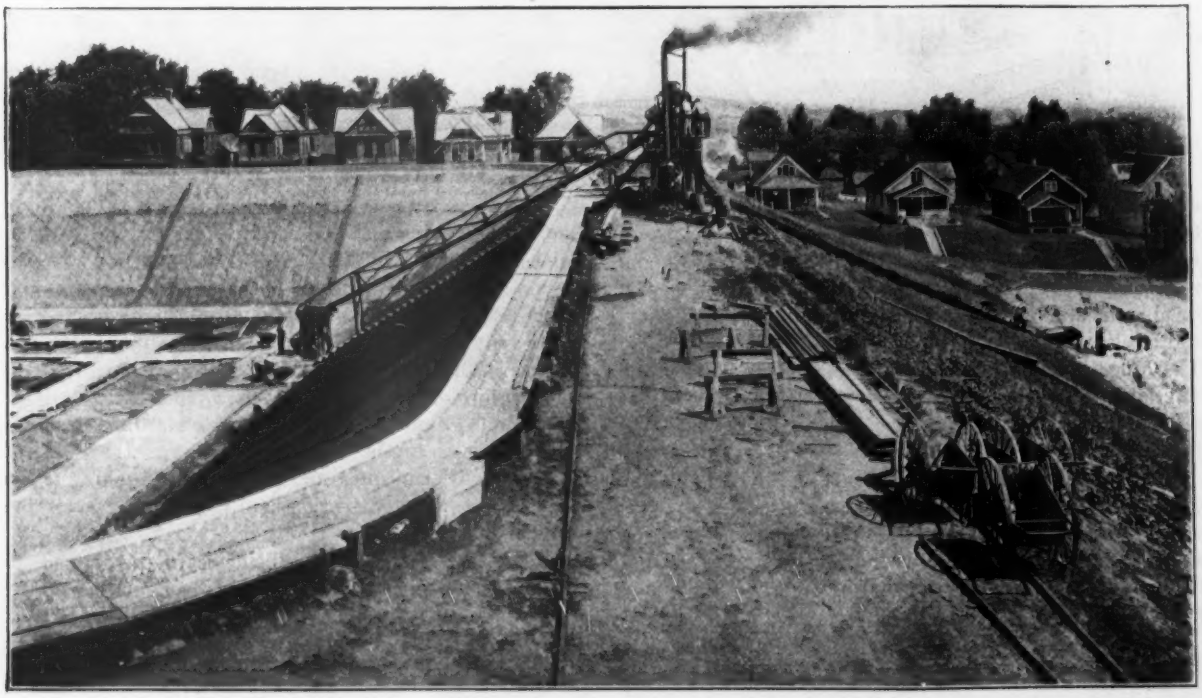


FIG. 2. MIXER AT WORK LINING BOTTOM OF RESERVOIR

FIG. 3. CRACKS IN OLD LINING

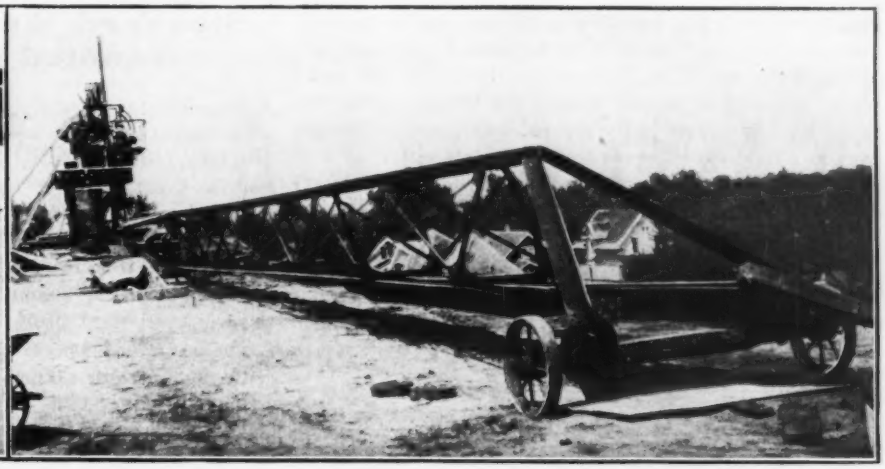


FIG. 4. CHUTE FRAME ON TOP OF RESERVOIR

signed by Homer V. Knouse, Construction Engineer of the Water District, for the lining of Basin 6 at the Florence Station of the Water District. This outfit consists of a Smith mixer mounted on a timber platform which was set on the top of the embankment, and provided with a feeding track extending down the outer slope and a chute extending down the inner slope. This mixing plant was complete in itself, was self-driven by a steam engine and remained in this one location throughout the relining of the basin.

The mixer was fed from the ground elevation outside the basin (Fig. 2) by a skip which traveled on a track laid down the slope and which was controlled from a hoisting cable at the mixer. The special track was framed at the mixer so that the skip would dump directly into the drum. Sand, stone and cement were all stored at the lower level and dumped into the skip as needed for each batch.

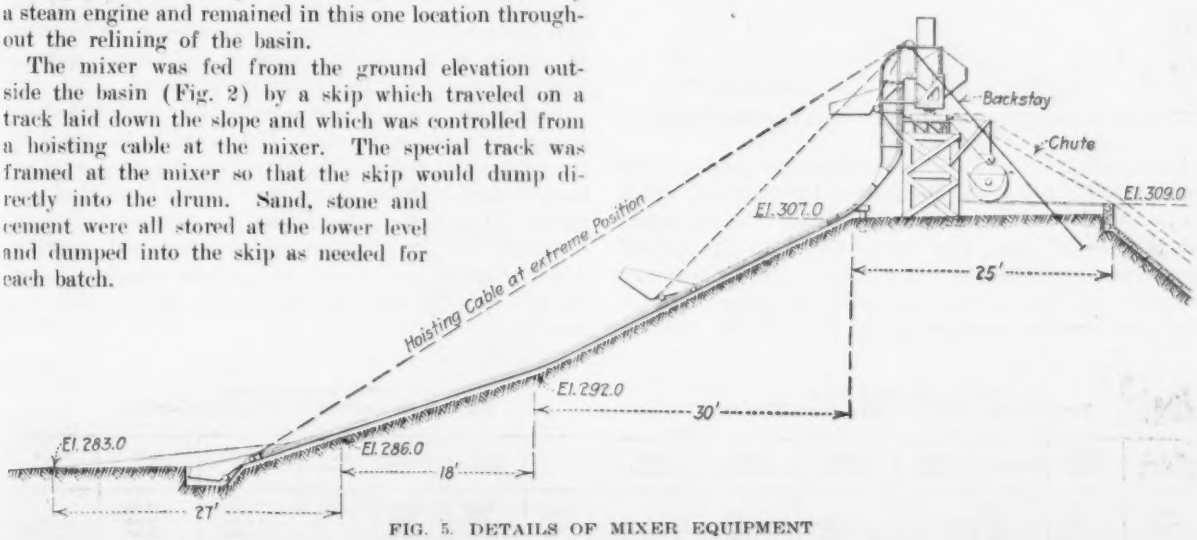


FIG. 5. DETAILS OF MIXER EQUIPMENT

The delivery from the mixer was made through a specially designed chute (Fig. 4) mounted on a structural frame which was laid parallel to the inner slope (Fig. 2). When the bottom was being concreted, this frame was fastened to the mixer and the concrete was fed directly into it and at the bottom was dropped through a hopper into buggies which were wheeled to the required location. In concreting the slope, the chute frame was detached from the mixer and rested on wheels running at the top and bottom of the reservoir. The concrete from the mixer was then carried in buggies to the top of the chute and fed down the slope to the required place. The chute was in sections so that it could be detached and the concrete allowed to spill at any part of the slope.

The work was done under the direction of Geo. T. Prince, Chief Engineer of the Metropolitan Water District of Omaha.

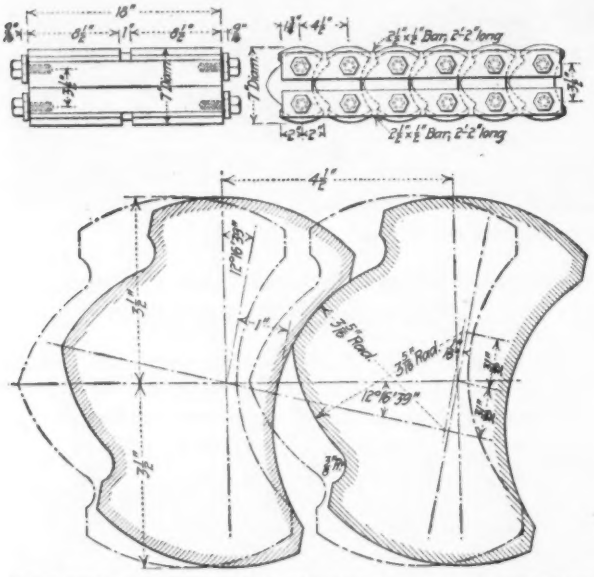
New Roller Shoe for Bridges Prevents Tipping

In the truss spans of the recently remodeled Herron Ave. bridge in Pittsburgh, use was made of a novel type of expansion bearing roller, developed by the Bridge Division of the city's Bureau of Engineering (T. J. Wilkerson, Division Engineer). Troublesome experience with the ordinary type of segmental roller on the new Point bridge showed that a change in design which would prevent the rockers from tilting over too far was desirable. At the Point bridge one of the 531-ft. spans stood during an unusually cold winter with no paving or sidewalk slabs in place. The rollers had been set to the correct position for full dead-load, and in consequence of the extreme temperature contraction and the fact that the bottom chord was not elongated to its normal dead-load length they were rocked beyond the safety point and tipped over, shearing the bolts in the side bars. To replace the rollers was a difficult problem, involving the lifting of the end of the span in very restricted space. It was accomplished by the use of nickel-chrome steel billets for lifting beams, and special bearings under eye-bar heads and pin ends.

The roller is shown in the drawing on the next page. One side of the segment is cut away, as is frequently done

to save weight, while the other is cut to a double-centered curve so designed that after a horizontal movement of ¾ in. either way from the vertical the roller will lock. While in the usual type of bearing the locking places the entire load on a few easily sheared bolts, in this design there is a roller-to-roller contact, giving stability.

The new rollers promptly justified themselves. After erection defective expansion in the long girder approach



NEW SELF-LOCKING ROLLERS FOR PITTSBURGH BRIDGE

at the south end was found to throw a considerable movement into the top of the last bent of the approach, which is tied to the bent supporting the span. The movement at the top of these two bents, added to the normal temperature elongation of the span during summer weather, has been enough to cause the rollers to reach their maximum position of roll, at times, and to lock.

Standard Water-Rate Forms Adopted in Montana

Standardized general, metered- and flat-service rules and regulations, for use by water-supply utilities in Montana, have recently been adopted by the Public Service Commission of that state. In connection with these rules standard forms for stating rates have also been adopted and all water-utilities are required to revise their schedules to this form. The forms of course do not prescribe the actual amount of the rates, as will be seen in the accompanying reprint of the new schedules.

The prescribed general rules require service to all applicants but permit asking a deposit of 1½ times the estimated regular bill. Interest at 6% is to be paid on deposits. The company taps the mains at its own expense, but the cost of laying and maintaining service pipes is borne by the consumers. Leaky plumbing fixtures have to be repaired immediately or water may be shut off. Special permits have to be secured for use of water on construction work, sprinkling, etc. Violation of the rules by a customer, or nonpayment of bills, is penalized by shutting off water; when service is resumed, the cost of turning water off and on may be collected—up to $1.

The flat-rate service rules penalize for serving outside persons without permission by shutting off water and adding the cost of this to the bill. Flat-rate bills are payable in advance. Additional fixtures may be installed on notice to the water company; reductions may be similarly cared for with a reduction of charge.

Under the metered-service rules, any customer may have a meter set on request. Meters are to be owned by the companies, and may be placed on any service where there is waste. When a customer desires more than one meter on one service line, he may be required to pay $1 a month for installation, maintenance and reading. Where a meter has stopped or has been tampered with, the bill may be based on the average of the past two months.

Commercial Meter Rates.
For Each 100 Cubic Feet (750 Gallons) Monthly.

	Cubic Feet	Gallons	Rate Cents	Total Cu. Ft.	Total Gallons	Total Amount
First	100	750	.....	100	750	.....
Next	100	750	.....	200	1,500	.....
"	100	750	.....	300	2,250	.....
"	100	750	.....	400	3,000	.....
"	200	1,500	.....	600	4,500	.....
"	200	1,500	.....	800	6,000	.....
"	200	1,500	.....	1,000	7,500	.....
"	200	1,500	.....	1,200	9,000	.....
"	300	2,250	.....	1,500	11,250	.....
"	300	2,250	.....	1,800	13,500	.....
"	400	3,000	.....	2,200	16,500	.....
"	400	3,000	.....	2,600	19,500	.....
"	400	3,000	.....	3,000	22,500	.....
"	500	3,750	.....	3,500	26,250	.....
"	500	3,750	.....	4,000	30,000	.....
"	500	3,750	.....	4,500	33,750	.....
"	500	3,750	.....	5,000	37,500	.....
"	1,000	7,500	.....	6,000	45,000	.....
"	1,000	7,500	.....	7,000	52,500	.....
"	1,000	7,500	.....	8,000	60,000	.....
"	1,000	7,500	.....	9,000	67,500	.....
"	1,000	7,500	.....	10,000	75,000	.....
"	5,000	37,500	.....	15,000	112,500	.....
"	5,000	37,500	.....	20,000	150,000	.....
"	5,000	37,500	.....	25,000	187,500	.....
"	5,000	37,500	.....	30,000	225,000	.....
"	5,000	37,500	.....	35,000	262,500	.....
"	5,000	37,500	.....	40,000	300,000	.....
"	10,000	75,000	.....	50,000	375,000	.....
"	10,000	75,000	.....	60,000	450,000	.....
"	10,000	75,000	.....	70,000	525,000	.....
"	10,000	75,000	.....	80,000	600,000	.....
"	10,000	75,000	.....	90,000	675,000	.....
"	10,000	75,000	.....	100,000	750,000	.....
"	10,000	75,000	.....	110,000	825,000	.....
"	10,000	75,000	.....	120,000	900,000	.....
"	10,000	75,000	.....	130,000	975,000	.....
"	10,000	75,000	.....	140,000	1,050,000	.....
All over			.....	140,000	1,059,000	.....

Industrial Meter Rates.
For Each 100 Cubic Feet (750 Gallons) Monthly.

	Cubic Feet	Gallons	Rate Cents	Total Cu. Ft.	Total Gallons	Total Amount
First	3,000	22,500	.....	3,000	22,500	.....
Next	1,000	7,500	.....	4,000	30,000	.....
"	1,000	7,500	.....	5,000	37,500	.....
"	5,000	37,500	.....	10,000	75,000	.....
"	5,000	37,500	.....	15,000	112,500	.....
"	5,000	37,500	.....	20,000	140,000	.....
"	5,000	37,500	.....	25,000	187,500	.....
"	5,000	37,500	.....	30,000	225,000	.....
"	10,000	75,000	.....	40,000	300,000	.....
"	10,000	75,000	.....	50,000	375,000	.....
"	10,000	75,000	.....	60,000	450,000	.....
"	10,000	75,000	.....	70,000	525,000	.....
"	10,000	75,000	.....	80,000	600,000	.....
"	20,000	150,000	.....	100,000	750,000	.....
"	20,000	150,000	.....	120,000	900,000	.....
"	20,000	150,000	.....	140,000	1,050,000	.....
"	20,000	150,000	.....	160,000	1,200,000	.....
"	20,000	150,000	.....	180,000	1,350,000	.....
"	20,000	150,000	.....	200,000	1,500,000	.....
"	50,000	375,000	.....	250,000	1,875,000	.....
"	50,000	375,000	.....	300,000	2,250,000	.....
"	50,000	375,000	.....	350,000	2,625,000	.....
"	50,000	375,000	.....	400,000	3,000,000	.....
"	100,000	750,000	.....	500,000	3,750,000	.....
"	100,000	750,000	.....	600,000	4,500,000	.....
"	100,000	750,000	.....	700,000	5,250,000	.....
"	100,000	750,000	.....	800,000	6,000,000	.....
"	100,000	750,000	.....	900,000	6,750,000	.....
"	100,000	750,000	.....	1,000,000	7,500,000	.....
"	200,000	1,500,000	.....	1,200,000	9,000,000	.....
"	200,000	1,500,000	.....	1,400,000	10,500,000	.....
"	200,000	1,500,000	.....	1,600,000	12,000,000	.....
"	200,000	1,500,000	.....	1,800,000	13,500,000	.....
"	200,000	1,500,000	.....	2,000,000	15,000,000	.....
"	200,000	1,500,000	.....	2,200,000	16,500,000	.....
"	200,000	1,500,000	.....	2,400,000	18,000,000	.....
"	200,000	1,500,000	.....	2,600,000	19,500,000	.....
"	200,000	1,500,000	.....	2,800,000	21,000,000	.....
All over	200,000	1,500,000	.....	3,000,000	22,500,000	.....
				3,000,000	22,500,000	.....

MONTANA STANDARD FORM FOR METERED WATER-SERVICE RATE SCHEDULE

1. Apartments	[1] Not over 5 rooms or persons	$
	Each additional room	
	Each additional person	
2. Bakery	[2] Using not more than 1 barrel flour per day	
	Each additional barrel	
3. Banks	[2] Not more than 5 persons	
	Each additional person	
4. Barber Shops	[2] One chair	
	Each additional chair	
5. Barrel	Each time filled	
6. Bath, Tubs	[3] Private, one	
	Each additional one	
	Public, one	
	Each additional one	
Shower	[3] Private, one	
	Each additional one	
	Public, one	
	Each additional one	
7. Beer Pumps	Each	
8. Blacksmith Shop	[2] One fire	
	Each additional fire	
9. Boarding House	[1,2] Not more than 5 persons	
	Each additional person	
10. Book Bindery	[2] Not more than 5 persons	
	Each additional person	
11. Bottling Works and Breweries	[2] Not more than 5 persons	
	Each additional person	
12. Brickyard	[3] Not more than 5 persons	
	Each additional person	
13. Building and Construction	Brick, per 1000	
	Cement walk, per 100 sq. feet	
	Concrete work, per cubic yard	
	Lime or cement, per barrel	
	Plastering, per 100 sq. yds. 1 coat	
	2 coats	
	3 coats	
	Settling earth, per 10 cu. yds.	
	Stone work, per perch (16½ c. f.)	
14. Butcher Shop	[2] Not more than 5 persons	
	Each additional person	
15. Cement	See Building.	
16. Church	[2] One cold-water faucet	
	Each additional one	
	Each hot-water faucet	
17. Cistern	Each 100 cu. ft., Min. c. f.	
	Each additional 100 cu. ft.	
18. City Building	[1,3] One cold-water faucet	
	Each additional one	
	Each hot-water faucet	
19. Concrete	See Building.	
20. County Building	[1,3] One cold-water faucet	
	Each additional one	
	Each hot-water faucet	
21. Cows	One cow	
	Each additional cow	
22. Dairy	Not more than 5 cows	
	Each additional cow	
23. Dwelling	[3] Not more than 5 rooms or persons	
	Each room in excess of 5	
	Each person in excess of 6	
24. Elevators, Hydraulic	Not more than two stories	
	Each additional story	
25. Foundry	[3] Not more than 5 persons	
	Each additional person	
26. Fountain	¼" nozzle / ⅜" nozzle	
	½" " / ¾" "	
	¾" " / 1" "	
27. Fire Hydrant	Municipal, 1st hydrant	
	Each additional one	
	Private, first hydrant	
	Each additional one	
28. Fire Protection	1" pipe / 1¼" pipe / 2½" pipe	
	1½" " / 2" " / 2½" "	
Stand Pipes and Automatic Sprinklers	1½" " / 2¼" " / 3" "	
	1" " / 3" "	
	1¼" " / 4" "	
	2" " / 6" "	
29. Garage	[2] Private, one car	
	Each additional car	
	Wash rack, one car	
	Each additional car	
Commission recommends meter rate	Public, 5 cars or less capacity	
	Each additional 5 cars	
	Wash rack, 5 cars	
	Each additional 5 cars	
30. Government Building	[1,2] One cold-water faucet	
	Each additional cold-water faucet	
	Each hot-water faucet	
31. Greenhouses	[2] Each 100 sq. ft. of floor area	
32. Halls, Lodge rooms	[2] One cold-water faucet	
	Each additional one	
	Each hot-water faucet	
33. Heating Plant (Steam or Hot Water)	First 1,000 c. f. heating space	
	Each additional 1,000 cu. ft.	
34. Hotel	[1,2] Base Rate: Kitchen dining room and sitting room	
	Each additional room	
35. Hydrant—Yard	Not more than 5 persons	
	Each additional person	
36. Ice Cream Parlors	[1,2] One table or counter	
	Each additional one	
37. Jail	[3] One cold-water faucet	
	Each additional one	
	Each hot-water faucet	
38. Laundry, Hand	[3] Not more than 5 persons	
	Each additional person	
Steam	[3] One washing machine	
	Each additional one	
39. Lavatory, Private	Private, one	
	Each additional one	
	Public, one	
	Each additional one	
40. Lodging House	[1,2] Not over 10 rooms	
	Each additional room	
41. Market, Meat, Fish, Vegetable	[3] Not more than 5 persons	
	Each additional person	
42. Municipal Stables	Two animals, 1 vehicle	
	Each additional animal	
	Each additional vehicle	
43. Manufactories and Shops, N. O. S. [3]	[3] Not more than 5 persons	
	Each additional person	
44. Office Building	[3] Each room or office	
45. Photograph Gallery (Commission recommends meter rate)	[3] Not more than 5 persons	
	Each additional person	
46. Printing Office	[3] Not more than 5 persons	
	Each additional person	
47. Railroad Depot	[3] Not more than 5 persons	
	Each additional person	
48. Restaurant	[1,3] 12 chairs or stools or less	
	Each additional 4 chairs or stools	
49. Saloon	[1,3] Not more than 5 persons	
	Each additional person	
50. School	[1,3] Not more than 30 pupils	
	Each additional 5 pupils	
51. Sink, Private	One, not more than 5 persons	
	Each additional sink	
	Each additional person	
52. Soda Fountain	[1] Each one fountain	
53. Stable, Livery	[3] 4 stalls (2 double) & 2 vehicles	
	Each additional stall	
	Each additional vehicle	
Private	[3] One animal and one vehicle	
	Each additional animal	
	Each additional vehicle	
54. Sprinkling	Lawn, sidewalk, etc., 1st 25 ft. front	
	Each additional foot	
55. State Building	[1,3] One cold-water faucet	
	Each additional one	
	Each hot-water faucet	
56. Steam Engines	Each horse power, per hr. per day	
Traction	Each time filled	
57. Store, Drug	[1,3] Not more than 5 persons	
	Each additional person	
Grocery, Candy, Fruit	[1,3] Not more than 5 persons	
	Each additional person	
Wholesale Liquor	[1,3] Not more than 5 persons	
	Each additional person	
N. O. S. [3]	[1,3] Not more than 5 persons	
	Each additional person	
58. Tanks, Portable	Each time filled	
59. Theater	[3] One cold-water faucet	
	Each additional one	
	Each hot-water faucet	
60. Tubs, Private Laundry	One cold-water faucet	
	Each additional one	
	Each hot-water faucet	
61. Urinal, Private	One, self-closing	
	Each additional one	
	One, continuous flow	
	Each additional one	
Public	One, self-closing	
	Each additional one	
	One, continuous flow	
	Each additional one	
62. Water-Closet, Private	One, self-closing	
	Each additional one	
	One, continuous flow	
	Each additional one	
Public	One, self-closing	
	Each additional one	
	One, continuous flow	
	Each additional one	

Minimum Meter Charges.

Size	Min. Mo. Chg.	Size	Min. Mo. Chg.
¾"		¾"	
1"		1"	
1¼"		1¼"	
1½"		2"	
2"		2½"	
2½"		3"	
4"		6"	

[1] Includes sink and hot and cold water faucets.
[2] Does not include bath, urinal, water-closet.
[3] Not otherwise specified.

MONTANA STANDARD FORM FOR FLAT-RATE WATER-SERVICE SCHEDULE

Computing the Stresses in the Quebec Rocker Casting

In previous issues of *Engineering News* it has been explained how the cause of the disaster in the Quebec bridge erection on Sept. 11 was traced to the breakage of the steel rocker casting between the southwest end shoe of the bridge and the lifting girder.

The question asked by engineers everywhere is, Why did this casting break? Was it designed of sufficient strength? What were its loads and stresses?

Permanent Stretching of the Southeast Hanger Chains

A new fact of great importance to this question has been revealed by careful measurements just made to determine whether the hanger chains suffered any permanent stretch during the fall of the span. The measurements were made by tape, measuring from the lowest free pinhole of each chain link to the lowest open hole of the link next below. *The chains of the southeast hanger show 3/8-in. to 5/8-in. stretch in each 30-ft. link!* A slight stretch, 1/16 in. to 1/8 in. per link, was found in the southwest hanger chains. The north hangers have not yet been measured, but there is no special reason to expect a stretch here.

The significant conclusion follows from the great stretch of the southeast chains that this hanger was subjected during the fall to an excess load of something between 60% and 100%. Tests on steel bars like those of the chain, made two years ago for the bridge company, showed elastic limits ranging around 27,000 lb. per sq.in. stress on the net section. Because of the small length of net section in the chain links, and the large stretch, it is believed by those closest to the work that a stress of at least 30,000 lb. per sq.in. on the net section must have been acting when this stretching occurred. Since the dead-load stress was only about 17,000 lb. per sq.in., the excess load during the fall must have attained a value of over 60%.

This excess is the load which was thrown on the southeast hanger (after the southwest support had failed) by the resistance of the portals and lateral systems. The top laterals, which were the weakest elements, consisted each of four 4x4x1/2-in. to 5/8-in. angles of nickel steel, with end connections of unusual strength. Computation shows that the force required to tear these laterals, applied at one corner of the span, is not far below the 1,200-ton. dead-load reaction at that corner. The picture taken during the fall proves that the top laterals tore bodily.

Thus the southeast rocker withstood at least 60% more than normal load, *without failing*, the latter fact being fully shown by the evidence presented in *Engineering News* of Sept. 21. This proved high strength of this rocker is striking, in view of the failure of the adjacent southwest rocker, and may not be lost sight of in considering the question of the stresses to which the rockers were subjected.

Load on the Failed Rocker

The entire end support of the suspended span was designed for 3,000,000 lb. load at each corner. This figure represents a weight estimate of 2,500,000 lb., and 20% allowance for impact. It includes the weight of the rocker support itself.

Since the span was perfectly quiescent, there can be no question of impact addition at the time of the failure. The load at this time was 2,370,000 lb. There could not then have been any excess of load at one or another corner due to uneven action of the jacks, because the span was hanging from the pins in the fixed jacking girders (see sketch Fig. 2), and therefore was in balanced, unstrained condition.

With respect to load on the rocker at other times, increased load due to lifting one corner a trifle ahead of the adjoining corner was a possibility. The lifting operations were, however, held under such control that the adjoining ends were never more than 1/4 in. apart in level (1/2 in. on the indicator). If by chance the two ends of the span were momentarily in opposite phase with respect to out-of-level condition, there would be a twist in the span corresponding to 1/2 in. lift of one corner. The lifting force required for this lift is small, and does not add appreciably to the normal shoe reaction.

All the rockers carried the span while on falsework at Sillery Cove, and here they bore an overload from track, a 30-ton locomotive crane, and material trains. Careful reëstimates of this overload give its static amount as more than 10%, apart from the impact and vibration effect of the locomotive crane. Thus, the failed rocker had carried perhaps 15% overload without breaking. In addition it had resisted the longitudinal tipping moment arising from pin friction as the span slid along the longitudinal (lower) rocker pin because of expansion on the falsework. This friction is estimated at possibly 8%; its overturning lever arm was about 10 in.

The Bridge Company's Stress Calculations

The St. Lawrence Bridge Co., in accordance with its policy of giving to the profession full information as to all the facts and circumstances in connection with the disaster, has furnished at our request a calculation sheet, which they state is "a copy of our calculations in designing the casting," and it is printed in full below.

The unit stresses (for erection material) were fixed by the specifications at 20% higher than those allowed in parts of the permanent structure. Thus the figures of 18,000 lb. per sq.in. for rolled steel and 16,000 lb. per sq.in. for steel castings, as specified for parts of the bridge, were raised for the erection appliances to 21,600 lb. per sq.in. for rolled steel and 19,200 lb. per sq.in. for steel castings. Later, special consideration of the chain hangers, based on elaborate tests, led to an agreement between the bridge company and the Board of Engineers to limit the hanger tension to 20,000 lb. per sq.in. (for load plus 20% impact). In this way it came about that substantially equal unit stress was employed for the chain bars and the steel castings.

The bridge company's calculation sheet, below, has three parts.

The first relates to the bending effect on the lower bracket arm of the rocker. The calculation involves

the assumption that the casting does not bear on the pin all the way, but deflects away from the pin at the ends; and this action is assumed to be just enough to reduce the bending action at the root of the bracket to the allowed stress intensity of 20,000. The second computation deals similarly with the lower pin. The third, still using the same method of calculation, deals with the lower shoe casting, which rests on the lifting girder.

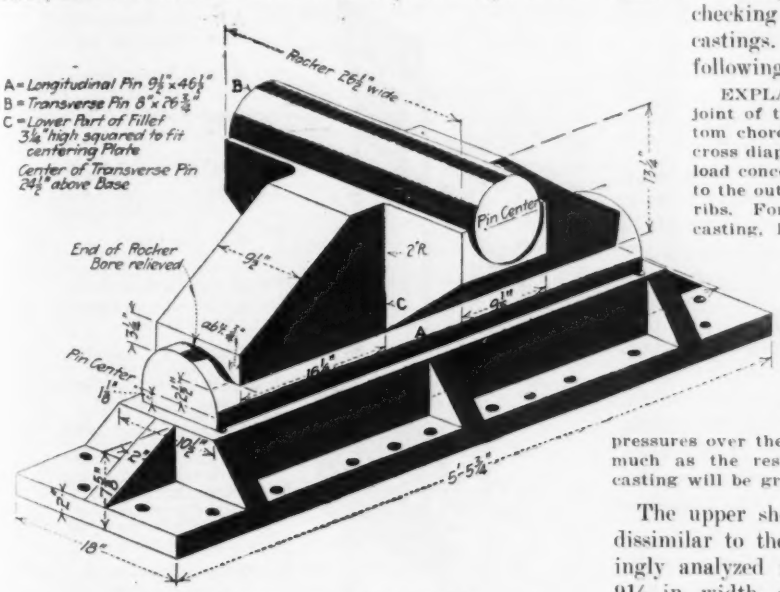
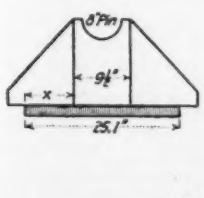


FIG. 1. ROCKER AND LOWER SHOE

Sheet lead ⅛ in. thick under shoe. Centering plates bolted to sides of shoe and projecting up to fit tight against side bracket at C.

Total load on castings including 20% impact = 3,000,000 lb. Distribution of load allowing bending units of 20,000 lb. per sq.in. for steel castings and 30,000 lb. per sq.in. for pins.



$$\text{Stress per unit of length} = \frac{3{,}000{,}000}{9\frac{1}{2} + 2x}$$

$$M = \frac{3{,}000{,}000}{9\frac{1}{2} + 2x} \times \frac{x^2}{2} = \frac{3x^2}{19 + 4x} 10^6$$

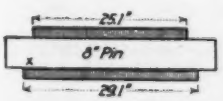
Sec. Mod. of casting = 182.5

Allowable Mom. = 20,000 × 182.5 = 3.65 × 10^6

$$\frac{3x^2}{19 + 4x} = 3.65; \qquad x = 7.8 \text{ in.}$$

Casting will distribute load 9.5 + 7.8 × 2 = 25.1 in.

$$\text{Bearing unit} = \frac{3{,}000{,}000}{25.1 \times 8} = 15{,}000 \text{ lb. per sq.in.}$$



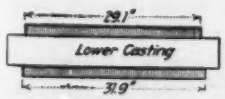
$$\text{Mom. on pin} = 1.5\frac{x}{2} \times 10^6$$

Sec. Mod. of 8-in. pin = 50

Allowable Mom. = 30,000 × 50 = 1.5 × 10^6

$$1.5\frac{x}{2} = 1.5; \qquad x = 2 \text{ in.}$$

25.1 + 2 × 2 = 29.1 in.



$$\text{Mom. on casting} = 1.5\frac{x}{2} \times 10^6$$

Sec. Mod. = 52.3

Allowable Mom. = 20,000 × 52.3 = 1.046 × 10^6

$$x = \frac{1.046}{1.5} 2 = 1.4 \text{ in.}$$

Total distribution = 29.1 + 1.4 × 2 = 31.9

Note—The 8-in. pin was changed to a 9½-in. pin at the suggestion of the Board.

It will be seen, as the final result of this calculation, that the lower shoe is *supposed* to bear on the girder for a length of only 31.9 in., although actually the shoe is about twice this length.

Through the courtesy of C. N. Monsarrat, Chairman of the Board of Engineers, *Engineering News* has been furnished with a copy of the original calculations made in checking the design of the lifting-apparatus castings. The calculation is introduced by the following statement:

EXPLANATION OF ASSUMPTIONS—The XLO joint of the suspended span [at the end of the bottom chord] is designed by means of heavy vertical cross diaphragms and bottom plates to take this full load concentrated on the middle rib and distribute it to the outside ribs in proportion to the areas of these ribs. For this reason it is assumed that the upper casting, Pattern No. 210, delivers 75% of the load to the middle rib and 12½% to each of the outside ribs. It is also evident that the series of castings and pins, acting as a whole, will deflect more under a unit load than the surfaces against which they bear. For this reason the bearing pressures at or near the vertical axis of the castings and pins will be the greatest and therefore the following assumptions of uniformly distributed bearing pressures over the limited areas shown will be justified inasmuch as the resulting calculated bending stresses in the casting will be greater than can actually be the case.

The upper shoe, which is a cross-shaped casting not dissimilar to the rocker in its general form, is accordingly analyzed for a central load of 2,176,000 lb. on 9½ in. width, and end loads of 362,000 lb. each centering 24.6 in. from the middle of the shoe, and for a pin reaction distributed uniformly on the entire 26¾-in. length of the transverse rocker pin.

The ribs of the shoe are stressed to 18,400-lb. tension and 24,700-lb. compression if the side ribs carry this amount, but the longitudinal ribs have ample strength.

Same Method Followed in Check Calculations by Board of Engineers

To find how this 8x26¾-in. pin delivers the load to the top of the rocker casting, its bending-moment capacity at 30,000 lb. fiber stress is computed, and then by calculation it is found that if the reaction against the bottom of the pin is distributed over a length of 22.32 in., the overhang of load over reaction develops the full 30,600 lb. unit stress in the pin. The 22.32 in. length of reaction is accordingly taken to be the true length of distribution, and from it the stresses in the rocker casting are determined, as follows:

Upper or Transverse Bracket [of rocker casting].

Moment on Section a-a [at root of bracket].

$$\frac{\frac{1}{2}(22.3 - 9\frac{1}{2})}{22.3} \times 2{,}900{,}000 \times \tfrac{1}{2}(22.3 - 9\tfrac{1}{2}) = 2{,}650{,}000 \text{ in.-lb.}$$

Section modulus = 188.65 in.³.

$$\text{Bending fiber stress} = \frac{2{,}650{,}000}{188.65} = 14{,}000 \text{ lb. per sq.in.}$$

Lower or Longitudinal Bracket—

Section modulus of casting = 188.65 in.³ If casting is strained to 19,200 lb. per sq.in. in Section bb [at root of bracket], it will be distributing the 2,900,000-lb. load uniformly over length x. The moment the casting is resisting for this condition is 19,200 × 188.65 = 3,600,000 in.-lb. Therefore

$$\frac{2{,}900{,}000}{x} \times \frac{x - 9.5}{2} \times \frac{x - 9.5}{4} = 3{,}600{,}000$$

Solving for x, x = 25.4 in.

Calculation of 9½-in. Pin—

Section modulus of pin = 84.0 in.³ If pin is strained to 30,000 lb. per sq.in., acting as a cantilever beam, it will distribute the 2,900,000-lb. load uniformly over a length x. Moment pin is resisting is 84.0 × 30,000 = 2,520,000 in.-lb

$$\frac{2{,}900{,}000}{x} \times \frac{x}{2} \times \frac{x}{4} - 1{,}450{,}000 \times \frac{25.5}{4} = 2{,}520{,}000, \text{ or } x = 32\tfrac{1}{2} \text{ in.}$$

Calculation of Lower Shoe Casting—

Section modulus of casting = 39.92 in.³ Casting receives its load uniformly distributed over a length of 32½ in. and can distribute this load, while acting as a cantilever beam, uniformly over a length of x inches. Moment casting can resist = 39.92 × 19,200 = 765,000 in.lb.

$$\frac{2{,}900{,}000}{x} \times \frac{x}{2} \times \frac{x}{4} - 1{,}450{,}000 \times \frac{32.5}{4} = 765{,}000, \text{ or } x = 34.5 \text{ in.}$$

In addition to this the two ⅝-in. cover plates, which are well riveted together and to which the casting is bolted with 1¼-in. turned bolts, will distribute the load over a bearing length of 35.5 in.

The area of the diaphragm material covered by this bearing length of 35.5 in. is 99.3 sq.in., giving a bearing pressure per square inch of $\frac{2{,}900{,}000}{99.3} = 29{,}000$ lb. per sq.in., this unit pressure including the 20% of the lifted load as impact.

The Calculations Explained by Comparison with Other Computed Results

While the above calculations follow an unusual method, further explanation of them would be of little interest if the unit stresses were low or the casting unimportant. Under the circumstances of the case, however, it is essential that the calculation be studied closely to determine what degree of approximation it involves and, if not exact, how large an error it may introduce. The following explanatory statements are therefore added:

1. The calculation deals with a hypothetical condition, or a hypothetical set of castings and pins. The real support can be transformed into the one involved in the calculation by cutting off the ends of the lower shoe casting, so as to reduce its length from 65¾ to 31.9 in.; cutting off the ends of the lower pin so as to reduce its length from 46½ to 29.1 in., and cutting off the ends of the front and rear brackets of the rocker so that they project only 7.8 in. instead of 16¼ in. When all parts are brought into this condition, they are then strong enough to carry the load if distributed on them as assumed. The view being held that the real or longer castings and pins are stronger than what is left after cutting off pieces, it followed that the rocker support as designed was safe.

2. The method of calculation employed—namely, determining the length of bearing that will (with uniform distribution on that length) keep the bending stresses within *previously fixed* limits—might be applied to even smaller castings and pins with the same results, except that still shorter lengths of loading would be found. For example, the brackets of the rocker might be only 7¼ in. thick instead of 9½, in which case they would be only three-fourths as strong; yet the method of calculation would show the same bending stress of 20,000 lb. per sq.in., i.e., *it would show them to be just as safe as the thicker rocker brackets.* This process could be carried as far as desired, evidently.

3. The method of calculation ordinarily used, based on the assumption of uniform distribution of the load along the full length of the pin seat, gives much higher bending stresses in the rocker bracket: For 3,000,000 lb. load, 51,600 lb. per sq.in.; for 2,500,000 lb. load (net load after deducting the 20% impact addition), 43,000 lb. per sq.in.; for 2,370,000 lb., the actual load sustained on Sept. 11, 40,700 lb. per sq.in. These stresses pertain to the lower or longitudinal rocker brackets; they represent tensions in the lower edges of the rocker, each edge only ¾ in. wide.

This narrow edge, more susceptible to cracking than a flat or rounded face, was further affected by the presence of the reëntrant angle at the root of the bracket,

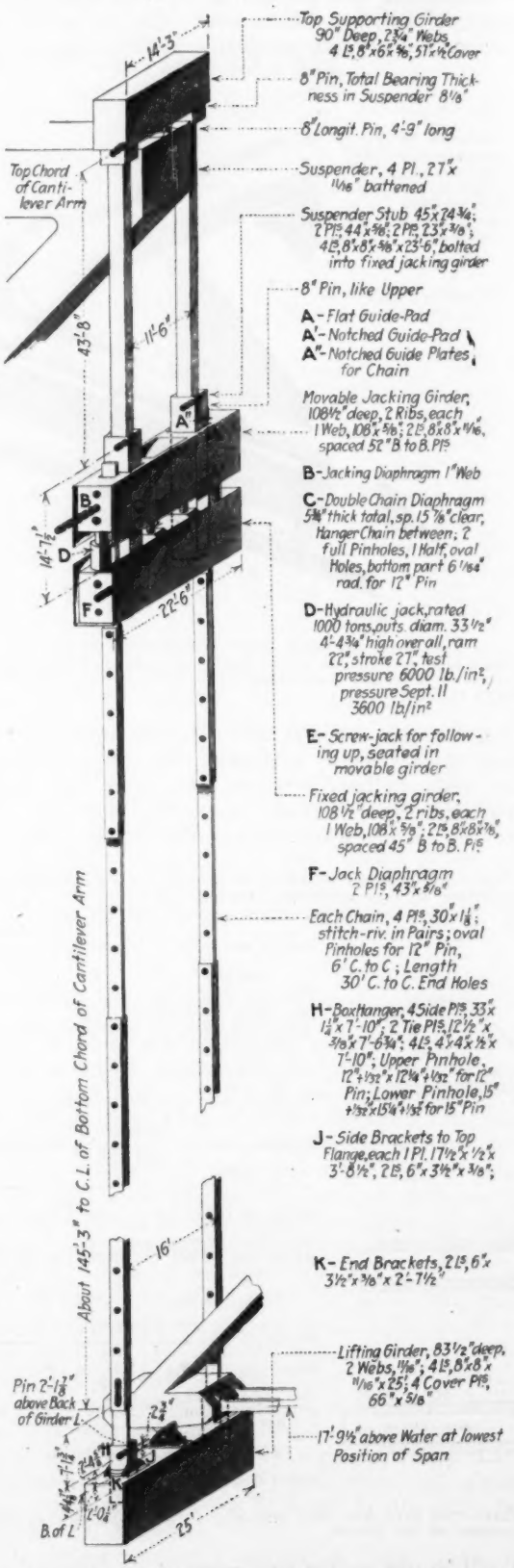

Top Supporting Girder 90" Deep, 2¾" Webs, 4 L⁸, 8"x6"x⅝", 51"x½" Cover
8" Pin, Total Bearing Thickness in Suspender 8⅛"
8" Longit. Pin, 4'-9" long
Suspender, 4 Pl., 27" x 11/16" battened
Top Chord of Cantilever Arm
Suspender Stub 45"x74¾"; 2 Pl⁸ 44"x⅝"; 2 Pl⁸ 23"x⅜"; 4 L⁸, 8"x8"x⅝"x23'-6", bolted into fixed jacking girder
8" Pin, like Upper
A - Flat Guide-Pad
A' - Notched Guide-Pad
A" - Notched Guide Plates for Chain
Movable Jacking Girder, 108½" deep, 2 Ribs, each 1 Web, 108"x⅝"; 2 L⁸, 8"x8"x 11/16", spaced 52" B to B. Pl⁸
B - Jacking Diaphragm 1" Web
C - Double Chain Diaphragm 5¾" thick total, sp. 15⅞" clear, Hanger Chain between, 2 full Pinholes, 1 Half, oval Holes, bottom part 6 1/64" rad. for 12" Pin
D - Hydraulic jack, rated 1000 tons, outs. diam. 33½" 4'-4¾" high over all, ram 22", stroke 21", test pressure 6000 lb./in², pressure Sept. 11 3600 lb/in²
E - Screw-jack for following up, seated in movable girder
Fixed jacking girder, 108½" deep, 2 ribs, each 1 Web, 108"x⅝"; 2 L⁸, 8"x8"x 7/16", spaced 45" B to B. Pl⁸
F - Jack Diaphragm 2 Pl⁸, 43"x⅝"
Each Chain, 4 Pl⁸, 30"x1⅛"; stitch-riv. in Pairs; oval Pinholes for 12" Pin, 6' C. to C; Length 30' C. to C. End Holes
H - Box Hanger, 4 Side Pl⁸, 33"x 1¼"x 7'-10"; 2 Tie Pl⁸, 12½"x ⅝"x 7'-6¾"; 4 L⁸, 4"x4"x ⅜"x 7'-10"; Upper Pinhole 12"+1/32"x 12¼"+1/32" for 12" Pin; Lower Pinhole, 15" +1/32"x 15¼"+1/32" for 15" Pin
J - Side Brackets to Top Flange, each 1 Pl. 17½"x ½"x 3'-8½", 2 L⁸, 6"x3½"x ⅜";
K - End Brackets, 2 L⁸, 6"x 3½"x ⅜"x 2'-7½"
Lifting Girder, 83½" deep, 2 Webs, 11/16"; 4 L⁸, 8"x8"x 11/16"x 25'; 4 Cover Pl⁸, 66"x⅝"
17'-9½" above Water at lowest Position of Span
About 145'-3" to C.L. of Bottom Chord of Cantilever Arm
Pin 2'-1⅞" above Back of Girder L.
B. of L.
14'-3"
43'-8"
11'-6"
14'-7½"
22'-6"
16'
25'

FIG. 2. PERSPECTIVE DIAGRAM OF ONE HANGER OF THE QUEBEC BRIDGE SUSPENDED SPAN, TO SHOW FLEXIBLE AND STABLE MANNER OF SUPPORT

where the longitudinal and transverse brackets join. This angle was filleted to 2-in. radius in the casting, but the lower part of this fillet had to be partly chipped away to make a bearing for the edge of the centering plate bolted to the lower shoe and extending up to engage the rocker.

4. If, on account of the deflection of the rocker brackets when under load, the bearing pressure be taken as zero at the front and rear ends and maximum over the central 9½-in. length of the rocker, varying uniformly thence to the ends, the bending stress at the root of the bracket is only about half as great. For a load of 3,000,000 lb. the stress is 28,000, for a load of 2,500,000 lb. it is 23,400, and for a load of 2,370,000 lb. it is 22,200 lb. per sq.in.

5. The greatest vertical load on the rockers occurred at Sillery Cove; taking it as 10%, it raised the bending stress at the root of the front bracket to 44,800 lb. per sq.in., if the pin bearing pressure was uniform, and 24,000 if the bearing pressure tapered down to zero at the ends.

6. The preceding figures for vertical load take no account of expansion stresses. The span at Sillery was arranged to slide on the longitudinal (lower) rocker pin and did so slide, a maximum amount of 2¼ in.; this was one-sided creep of the span, due to connection with the material track, and because of it the shoes at one end were then blocked against longitudinal motion. The sliding friction tends to overturn the rocker longitudinally, and thereby increases the pressure under the bracket toward which the expansion is taking place.

This effect increases the bending stress at the root of the rocker bracket somewhat. For 7½% friction, with 10-in. lever arm, the increase is about 3,000 lb. per sq.in. under the uniform-pressure condition of the rocker, and about 4,000 lb. per sq.in. for the tapered-pressure condition. These increments would not be simultaneous with the 10% excess load.

No damaging effects of the loading at Sillery Cove were noticed. This is in a measure negative evidence, as no close examination of the rockers was made. The last visit to the supports, for inspection of the centering plates just before lifting started, by George F. Porter and S. P. Mitchell, was made in early morning. At this time the rocker supports were fairly well in the dark and therefore this visit affords no data for judging of the condition of the castings.

Quality of the Castings

The steel castings for rockers, shoes, etc., were required to be of openhearth stock containing not less than 0.10% carbon at any period of the melt, and in ladle test not more than 0.04% phosphorus (or 0.06 for acid steel), 0.05 sulphur, 0.75 manganese, and 0.35 silicon. Tension tests from coupons (annealed) were to show 35,000 lb. per sq.in. elastic limit, 65,000 lb. ultimate strength, and 2% elongation in 2 in., besides a 120° bend on a diameter of twice thickness. These requirements were fixed by the specification for the permanent bridge structure.

The specification was fully met by the material furnished. The material was acid openhearth, made by the Canadian Steel Foundries Ltd. The test report from the foundry's laboratory shows for the chemical composition: Carbon, 0.26%; phosphorus, 0.033%; sulphur, 0.032%; manganese, 0.55%; and for test results: Elastic limit 36,300 lb. per sq.in.; maximum strength, 69,700 lb. per sq.in.; elongation, 29%; reduction of area, 44.7%.

The heat from which the rockers were cast included other castings, and it is not known from which casting the test coupon was taken. Nor can the coupon be located now for examination of fracture and structure. However, the process of molding, pouring and annealing was carried out in exactly the same way as for other highest-grade castings. The melt was treated with 1,265 lb. ferrosilicon and 525 lb. ferromanganese to 18 tons charged. The rockers were molded top down, bottom-gated, with four shrink heads taken off the sides of the top (the lower or longitudinal brackets) and rising 20 in. high above the casting. No welding or other curing of defects was done, it is stated very positively. Annealing was done at 1,700° to 1,800° F., and according to best recollections these castings were in the furnace 36 hr.

Figures and Facts Disprove Claims that Support of Span Was Unstable

A large number of inquiries have been made of *Engineering News* as to the stability conditions of the lifting chains that carried the span in hoisting.

The diagrammatic sketch, Fig. 2, with dimensions and make-up of the lifting rig, has been prepared to supply the needed data. It exhibits in full the ample provision for flexibility and self-adjustment of the suspension. The dimensions of the overturning and righting lever arms at the critical point—lifting girder and rocker —are given in full. The suspension pin of the lifting girder is shown to be 2¾ in. above the upper rocker pin, which assures the stability of the assemblage.

Quite apart from the sketch and figures, however, the facts of the accident as reported in full in *Engineering News* of Sept. 21 prove that the question of stability played no part in the fall of the span. Tipping of one or more of the lifting girders did not take place before the fall started. The severe thrust kick through the span which necessarily would have followed a primary tipping of one lifting girder was not observed. Tipping through an angle of nearly 90°, as would be inevitable if the fall was originated in that way, would have left indisputable evidence of its amount; but on the contrary the amounts of rotation shown by the several girders are relatively small; and the greatest rotation was found at the north girders, where it merely records the tipping of the entire span as the south end went under water. Further, a condition of low stability in the supports would not have permitted the north end to remain firmly seated while the south end, in falling, was twisting the span with force sufficient to destroy both laterals and main trusses. On the contrary, the behavior of the north ends is striking proof that the method of support was insensitive to even very large impact, torsional and longitudinal forces. In fact, considering the low metacentric height, a surprisingly high degree of stability was evidenced.

The preceding relates to rotation on the lowest joint of the hanger system, the pin in the top of the box hanger. The pin in the lower end of the box hanger is not a hinge but a shear connection transmitting the girder load to the hanger chain. The box hanger and girder are held rigidly together by a strong riveted connection at the top flange of the girder. This connection remained entirely undisturbed in the fall of the span.

Notes from Field and Office

Contractor speaks of night work and Sunday work—Concrete road finishing cheapened by a superintendent's kink—Water pipe on wheels for street flushing—Precision of difficult tunnel work assured by careful survey methods, New York and Milwaukee—Roller piledriver for sewer sheeting

Cost of Night and Day Work

By G. H. Hailey*

The article by Mr. Michel as to the relative cost of night and day shifts on construction work, in *Engineering News* of Aug. 17, is very interesting. Where any considerable amount of night work is performed, data as to its cost in comparison with day work would be very valuable to contractors.

We have not found it necessary to put on night shifts except in a few cases, and then only for a few nights to meet an emergency, so that we have no separate data as to the cost. In our concrete work we have very often continued running until 8 or 9 p.m. in order to complete a certain portion, such as the turning of an arch ring or a section of wall, but we have no records as to its cost in comparison with day work.

In a considerable number of cases where railway work was being done under traffic we have found it advisable to work on Sundays, there being less interference with the work on account of fewer trains. In such cases there is of course no question as to the Sunday work being efficient, and the same would apply to night work where the number of trains is less than in daytime. In a general way, however, I am of the opinion that, if the night work is charged with its proper share of the repair work and other overhead expenses incurred during the day, the cost will be 1¼ to 1½ that of day work.

*Chief Engineer, Cleary White Construction Co., Chicago.

Canvas Belt Used for Finishing Concrete Road Surfaces

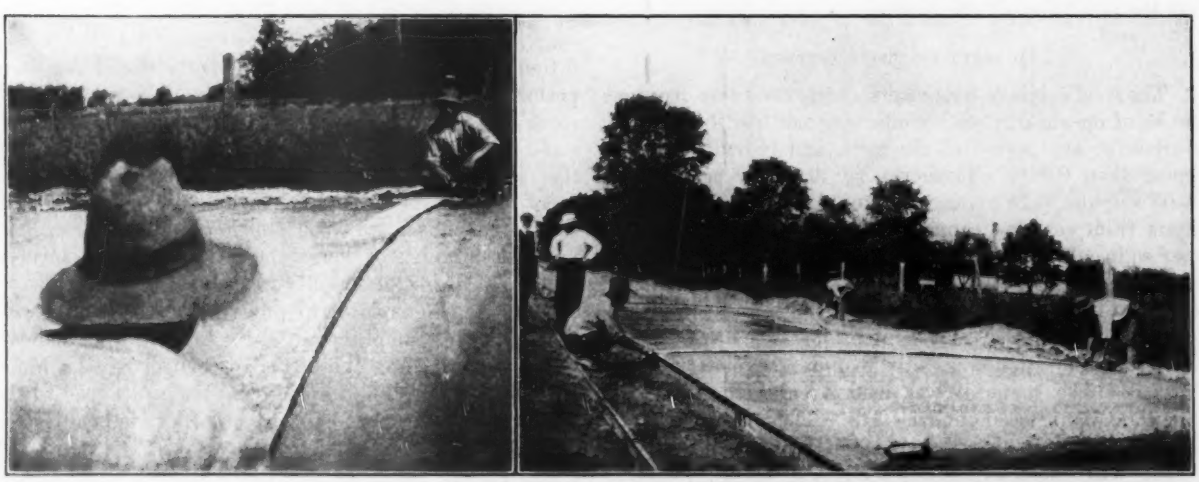
Instead of the usual method of finishing concrete pavement by means of trowels or floats which the finishers manipulate from a bridge spanning the roadway, a new device has been in use by the Board of County Road Commissioners, Wayne County, Mich., for a little over a year. This device is a strip of canvas belting 12 in. wide with handles bolted at each end. The strip is about 1 ft. longer than the width of the roadway.

The concrete is formed to the shape of the finished roadway in the customary manner by means of a wooden templet spanning the roadway and sliding on side forms. Two laborers follow this operation by pulling the canvas strip gently back and forth across the roadway, giving the smoothness of finish desired.

Patrick McConalogue, superintendent of construction for the Board of County Road Commissioners, is responsible for this method of road finishing. It seems that on a day when his finishers had quit he attempted to finish the roadway by drawing across the concrete surface a canvas tarpaulin used for protecting cement. This method rolled the stone at the surface and was rejected. Spying a strip of canvas about 4 ft. wide, he tried this and found that it worked fairly well. He doubled it once with better results, so he doubled it again to a width of about 12 in., and a very satisfactory finish was obtained. Concrete collected in the folds of the canvas, so later it was replaced by the canvas belting now in use.

While once over with this strip gives a good finish, Mr. McConalogue uses a second strip, a duplicate of the first, which is operated by two laborers whose chief duty it is to follow up the work, finish the edge of the roadway, and remove and carry forward the side forms. In this way any unevenness or roughness in the surface is eliminated as the work moves along.

The canvas belt used in securing the first finish is operated by two laborers from the gang working at the concrete mixer. As the mixer is being moved forward, these laborers drop back and finish the section just placed, 25 ft. of roadway surface being finished in about 3 min.



FINISHING CONCRETE ROAD SURFACES WITH CANVAS BELTING, WAYNE COUNTY, MICHIGAN

In this way three finishers at 33½c. per hr. have been done away with, resulting in a reduction in the payroll of practically $1 per hour.

Mr. McConalogue has tried rubber belting in place of the second "follow up" canvas belt and has been able to secure a glassy finish. However, as such a finish is undesirable for a roadway the canvas belts only are used. At the end of the day the concrete is thoroughly washed from the canvas belts.

East River Tunnel Surveys

By C. M. Holland*

The survey work in connection with driving the East River tunnels requires a large survey corps to be on duty both day and night in order to secure accurate and frequent checks upon the position of the tunnel shields. It is necessary that these shields be kept on the correct line and grade, as the cross-section of the tunnels has been reduced to a minimum for purposes of economy. Any considerable deviation from the theoretical alignment would have serious consequences that might delay the completion of the work as well as increase its cost.

Surface Work and Plumbing

The surface surveys and triangulation were completed by precise methods previous to construction operations, but all the work has subsequently been rechecked in order to guard against any possibility of error. The triangulation system selected in each case is a quadrilateral, with a side on each side of the river which could be measured and used as a check on the computed length as determined from the angular measurements. All the

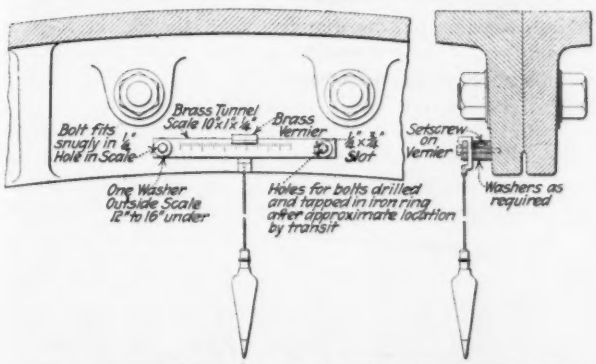

Brass Tunnel Scale 10"x1½"x¼"
Brass Vernier
Bolt fits snugly in ¼" Hole in Scale
⅛"x¾" Slot
Setscrew on Vernier
One Washer Outside Scale 12" to 16" under
Holes for bolts drilled and tapped in iron ring after approximate location by transit
Washers as required

FIG. 1. VERNIER ROOF SCALE USED IN EAST RIVER TUNNELS

angles were read by repetition, using a transit graduated to read to 10 in. of arc, and all measurements were made with standardized tapes corrected for pull and temperature. A system of coördinates was adopted to facilitate the computation of the tunnel alignments and the location of points for line dropping at the shafts.

The tunnel surveys are connected with the surface surveys by plumbing down shafts. A base length of 26 ft. was obtained in each case. These plumbings were repeated until successive plumbings in each shaft made it certain that the average result was well within any allowable error. In addition, check line droppings are made from time to time in order to determine whether the shaft points as already established have shifted. It is necessary to do this work on Sundays, as the vibration incidental to the operations in progress on week days makes precise work impossible. At first the shafts were plumbed about every third Sunday, and even at this late date they are plumbed about once every five or six Sundays.

*Tunnel Engineer, Public Service Commission, 159 Remsen St., Brooklyn, N. Y.

FIG. 2. LINE SIGHTING FROM AIR LOCK

The present distance of advance from the shafts averages about 1,500 ft. The longest distance any line will have to be extended from shaft to heading is about 3,000 ft., or over 100 times the length of the shaft base.

In the underground surveys also, continuous repetition of survey work is the only guarantee of precision, on account of the atmospheric conditions and the movement of the tunnel lining. In soft ground the tunnels shift slightly as the earth resettles around them, affecting line points often some distance back from the face of the heading. Furthermore, this is particularly true of tunnels driven in pairs, where, with one some distance ahead of the other, it often occurs when the second tunnel passes the first that there is a small shift in the line, which can be detected only by instrumental observations. Consequently, reliance is placed chiefly upon the continual repetition of observations with ordinary survey equipment rather than upon a single series of observations of a much more precise character.

Line Prolongation

The tunnel surveys in the East River tunnel work may be classified in three groups—the precise surveys, the construction surveys and the shield checks.

The precise surveys are usually made by parties of four men each, consisting of a chief of party, an instrumentman and two men for scale readings. All line points are carried on scales stud-bolted to the cast-iron tunnel lining (Fig. 1). The reading on each scale is fixed by means of a vernier graduated to read to 0.002 ft., and it is customary to estimate the reading to the nearest thousandth. Every effort is made to eliminate all in-

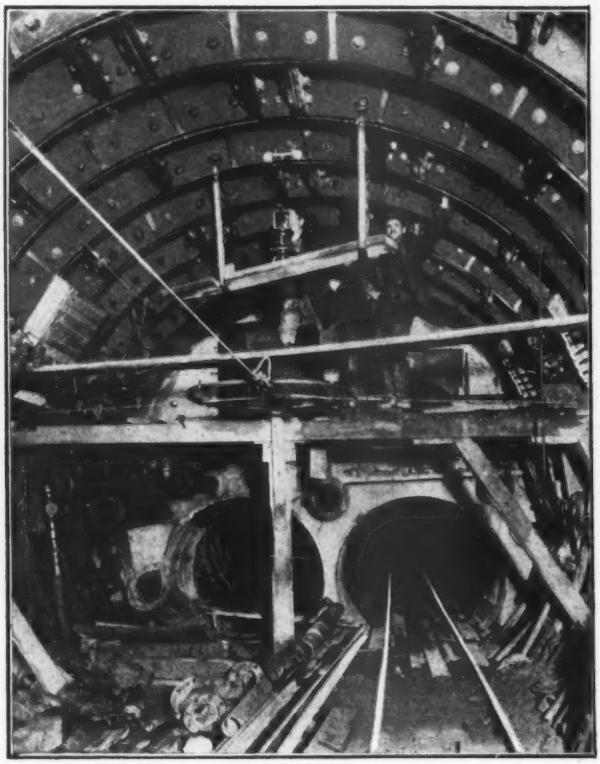


FIG. 3. INSTRUMENT PLATFORM SUSPENDED FROM ROOF

strumental errors in making these surveys, and the use of plumb-bobs for setting over or under points is eliminated. All line work is done by ranging the transits into line ("wiggling" or "bucking" into line), for which purpose the transit is set on a slow-motion shifting head. In addition, considerable emphasis is placed upon the proper lighting of the sights and keeping all equipment in correct adjustment. All angles are turned by repetition with transits reading to 10" of arc, and the measurements for reading the angle points are made, as in the case of base-line measurements, by standardized tapes corrected for temperature and pull. Errors of personal equation are worked out by having at least two parties working on each line independently, dependence being placed on a large number of observations by different instrumentmen. These precise surveys are run into each heading at least once a week when the atmospheric conditions are the best. The fog, which is a very serious factor to contend with in the survey work, sometimes makes it impossible to get long shots, but every effort is made to get shots at least 250 ft. long.

The construction surveys are made by parties of three men and consist of producing the precise survey lines ahead of the forward scale point, so that a line is always near the working face available for the shield check surveys. This line is carried forward daily. Scales are not used for setting this line, as no final readings could be maintained close up by the shield, so that this survey line is fixed by means of spads driven into boards wedged in between the flanges of the cast-iron lining. On account of the short distance which these surveys are carried in advance of the precise lines it is not customary to work to any great degree of precision, as the results are required to be only approximate.

All line work is carried along the roof of the tunnel, using suspended platforms (Fig. 3).

Controlling the Position of the Shield

To keep these shields on the correct alignment, check measurements are required each time a shield is moved. These shield check surveys consist of determining the alignment of the diaphragm of the shield (center), the alignment of the tunnel lining already erected and particularly the alignment of the last ring of iron erected. The transits are provided with a level on the telescope, and from a near-by benchmark the elevation of the shield and of the top of the last ring erected is obtained from the same setup.

As the completed tunnel under the action of the shield jacks always moves, except in very firm ground, it is necessary to make all measurements from a survey line, as dependence cannot be placed upon the completed structure. The reference line used is a radial line reëstablished by the construction survey party every 24 hr. and marked on the lining. It is tied in to points set some 20 ft. back in the tunnel, so that it can be checked for any movement.

Measurements are taken from this radial line on each side of the tunnel to points in the shield which determine how much one side of the tunnel is in advance of the other with relation to the proper direction of the tunnel (Fig. 4). These measurements are designated as the "lead" of the shield and are taken by the inspector in the heading as the shield is pushed. The foreman in charge of the shove is kept continually informed as to whether the proper leads are being maintained, and he operates his jacks accordingly.

The pointing of the shield for grade is fixed by reading to a point on the diaphragm of the shield from a plumb-line. The plumb-line is of a known length, and the distances to the diaphragm from this plumb-line vary with the grade on which the shield is traveling, so that the pointing of the shield to the tunnel grade can always be determined by reading the plumb-line. These readings are made continually during the shove; and, as in the case of the side leads, the foreman is kept informed as to how his shield is traveling. The method of shoving the tunnel shield and reading of leads and plumb is shown by Figs. 4 and 5. On the present work it has been unusual to have the line or grade of the completed structure vary more than 2 in. from the theoretical, and when a greater deviation than this has occurred it has been due to the shield encountering strata of different hardness or some foreign substance that has caused the shield either to settle or to rise abnormally. When this happens, every

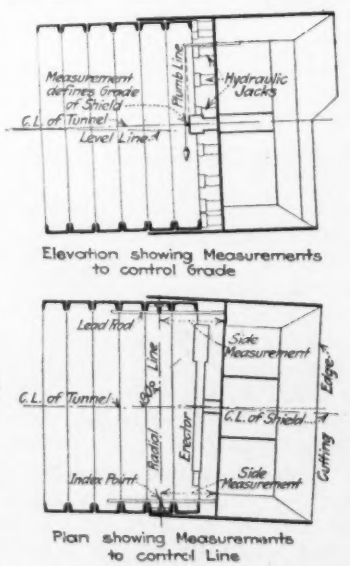


FIG. 4. CHECK MEASUREMENTS MADE AT EACH SHOVE OF SHIELD

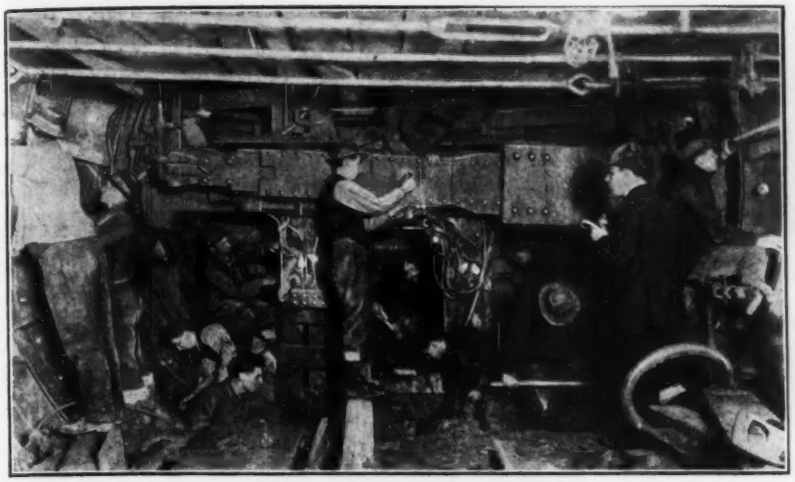


FIG. 5. SHIELD CHECK PARTY AT WORK

effort is made to give the shield a new plumb and a new side lead to overcome this action; but a shield weighing more than 100 tons and of considerable length will travel some distance before it plows itself back to the normal position. The greatest difficulty in driving a shield is to hold it to grade, as the character of the ground through which the shield is passing affects its grade more than its line, since the shield has a tendency to settle in soft ground due to the material moving out from under the shield back into the tunnel.

After each shove of the shield the instructions for the next shove are worked out from the data as to line and grade obtained on the center of the diaphragm of the shield, the side lead and plumb-line readings. From this information the grade and alignment of both the cutting edge and the tail of the shield are computed, showing not only the exact position, but the pointing of the shield relative to the correct line and grade. This is of the utmost importance, for it shows what changes are necessary in the side lead or plumbing to swing the shield back to the correct line and grade, and in addition determines whether a straight or a taper ring should be provided at the completion for the next shove.

The placing of the cutting edge of the shield in a proper position after making allowances for settlement and other considerations is worked out by experience. It is the all-important factor in determining the position of the tunnel, for where the cutting edge of the shield goes, there goes the completed tunnel.

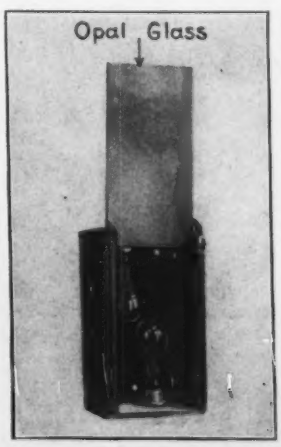
Varied Benchmarks for the Level Readings

Levels are divided up into the same general classes as alignment surveys, consisting of precise levels, construction levels and check levels. The precise levels are run by repetition at least once a week down into the tunnel heading, hitting the benches that have already been established by the construction survey party. The level party consists of three men, a chief of party who acts as recorder, an instrumentman and a rodman. The equipment used is ordinary survey equipment consisting of dumpy levels and Philadelphia rods. The precise benchmarks are formed by screwing stud bolts into the flanges of the cast-iron lining near the bottom of the tunnel, so as to avoid long rods which would be necessary in case the benchmarks were carried in the roof of the tunnel. The construction benchmarks are in the roof of the tunnel, because it is more convenient to work with these from the traveling platform that follows immediately behind the shield. The shield checker has for his benchmark a reading on the spad under which he sets for line, so that instead of requiring a rodman to give a backsight with a rod he measures from the spad down to the center of his telescope, which gives him close enough elevation for any one individual shield check. To take every opportunity for increasing the precision of the survey work and guarding against error, cross-checks between tunnels are obtained about every 500 ft. by driving a 2-in. pipe from one tunnel to its mate (the eight tunnels in question are driven in pairs, at South Ferry, Old Slip, 14th St. and 60th St.), through holes drilled in the shell at points computed to match. The pipe itself gives a check on the survey work, but in order to close the traverse the angle through the pipe is read, the distance is measured with a tape, and levels are read.

Survey Routine in Shore Tunnel, Milwaukee

Efforts at special accuracy were made in the instrumental work in the Shore tunnel of the new Milwaukee water intake to insure correct direction of the headings and precise meeting. The tunnel is attacked from four headings starting from two shafts. Compressed air is used in all headings. One of the shafts is offset from the tunnel, and the airlock for both headings from this shaft is located in the connecting drift. The two headings are at fractional angles to the line of the drift, necessitating work to single seconds in turning the angles. In the headings it was necessary to give line for the concrete forms at frequent intervals.

The tunnel center line was extended forward to the excavation face twice a week. This particular line work consisted in establishing the center line upon "screw eyes" (screws with flat heads, perforated to receive a plumb-bob string) fastened into 2x4-in. wood blocks set in the center line of the arch when the concrete was placed. These points were placed 30 to 40 ft. apart. The last three screw eyes in position were used for establishing the center line forward, the transit being stationed under No. 1 of the screw eyes and foresight being taken on No. 3 and checking on No. 2 (No. 3 being the nearest to the heading). This work did not require high precision, as all center-line screw eyes were rechecked every two weeks from the permanent or scale center line. The city inspectors employed these screw eyes only for "sighting in" by means of



ILLUMINATED SIGHTING BOX USED IN GIVING LINE IN SHORE TUNNEL

plumb-bobs, for establishing excavation center lines and checking the position of the front end of the forms for the concrete shell. The screw eyes were at all times available for sighting.

The permanent or roof-scale center line was established on roof scales (see *Engineering News*, June 15, 1916, p. 1151, for illustration of these scales, the screw eyes and a quick-shift instrument table) set in the arch concrete every 125 ft. The center line on the roof scales was carried forward every two weeks, the scales being read to 0.01 in., the total number of readings on each scale averaging six. After the last scale, or the one nearest the heading, was established for center line, the center-line screw eyes between the last scale and the heading were checked up from the same "set up" of the transit. The bottom of each roof scale was also used as a permanent benchmark.

The length of sights in extending the permanent center line was limited to about 500 ft. because of the presence of vapor, due to the compressed air.

An illuminated sighting box, called the "bait box," was used in the work, because plummet lamps were not distinct enough for accurate work. The box was equipped with two 200-watt 230-volt Mazda lamps. A 20-ft. cord attached to the box made it possible to connect anywhere to the tunnel lighting system. Held behind a suspended plumb-bob the box gave a clear sight.

The transfer of line from the surface into the tunnel was checked once and transfer of elevation was checked twice after the initial transfer at the beginning of tunneling. From the marks at the shaft bottom, line was transferred once and grade transferred twice through the airlock into the heading, using the roof scales. It would have been done oftener if it had not required removing the air-pressure, with the resultant danger of disturbing the soil conditions in the face.

The center line was established on the surface on 1¼-in. steel pins set in concrete monuments, near the shafts and adjacent to the tunnel terminal points; on 1¼-in.x4-ft. steel pins for permanent intermediate stations; and on 1x2x18-in. wood stakes for temporary intermediate stations. This surface center line was rechecked three times for alignment and twice for distance. The center line on the steel pins was the intersection of a cross marked in the steel by means of a chisel. The center line on the wood stakes was established on small brads. The slant distance or lineal measurement between stakes and steel pins was made by steel tape used with spring balance. A 12-lb. pull was maintained on the tape. Level readings for elevation were taken on the center points and corrections were accordingly made to secure the horizontal distances. All level readings were made from the target. All foresights were established by "double-centering" twice from the backsight, result of the double-centering being divided for true center.

In plumbing the shafts two 20-lb. plumb-bobs were used. The plumb-bobs were suspended on No. 8 piano wire and were immersed in oil contained in buckets at the shaft base.

The headings between the two shafts met late in July and very satisfactory results were obtained between the center and grade lines of the two headings.

The work is in charge of L. G. Warren, Resident Engineer, under the direction of George F. Staal, City Engineer.

Pile-Hammer Leads Mounted on Rollers

An unusual piledriving rig was employed in putting down wooden sheetpiling in excavating for a segment-tile sewer in St. Louis. The piling was driven by a 3,000-lb. Arnott steam hammer operating in a set of double fixed

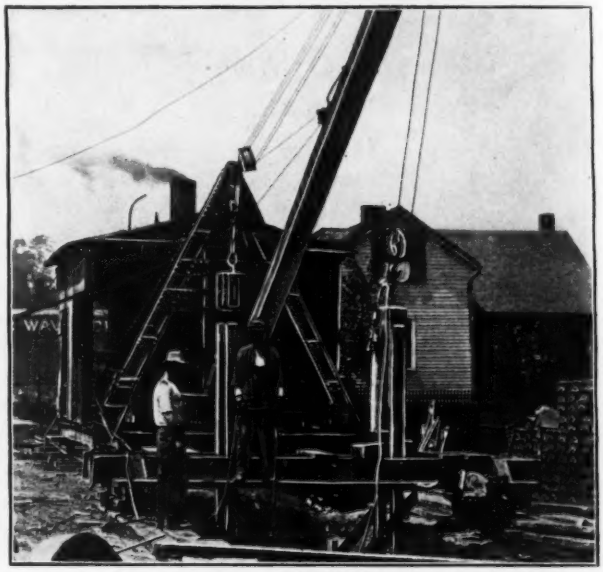


FIG. 1. CARRIAGE FOR SHEETPILE DRIVER LEADS

leads that could be moved by means of rollers located on each side of the ditch, as illustrated in Fig. 1. How the leads were braced is shown in Fig. 2.

The soil through which the sewer was constructed was quicksand overlain by yellow clay. Through the clay

FIG. 2. BRACING BETWEEN LEADS

the trench was braced by horizontal sheeting. Through the fine sand and quicksand, however, 3-in. tongue-and-grooved wooden sheetpiling was driven to a depth of 3 ft. below the flow line of the sewer.

Strengthening an Alley Bridge

The east approach of the Van Buren St. tunnel under the Chicago River is crossed by a 31-ft. alley, the east side of which is in line with the tunnel portal. The paving is carried on a concrete slab resting on shelf angles on the webs of 24-in. transverse girders. The depth of paving and slab was 20 in., the lower portion of the girders extending about 18 in. below the bottom of the concrete slab. These girders were placed in 1891, and in 1915 their condition was such that immediate repair or renewal was necessary. The former method was decided upon. There is very heavy team traffic in the alley, and to avoid interruption to business it was decided to do the work from below, the tunnel being closed on account of reconstruction of the west approach.

The lower flanges of the girders were wrapped with expanded metal, and strips of expanded metal in the form of an arch were sprung in on top of these flanges and between the webs of each pair of girders. Transverse reinforcing rods were placed in position between the girders. Forms were then made and supported on falsework. Grout pipes were placed in position, openings were calked with oakum, and a grout mixture composed of 2 parts cement, 2 parts powdered stone and 1 part torpedo sand was forced into place under 90-lb. air pressure by means of a pneumatic concrete mixer. A heavy I-beam was placed adjacent to the girder over the portal, and a concrete parapet wall was built in place of the former railing on this side of the alley.

The work was done by company force by the Chicago Railways Co., under the direction of John Z. Murphy, Electrical Engineer, and J. W. Harris, Tunnel Engineer.

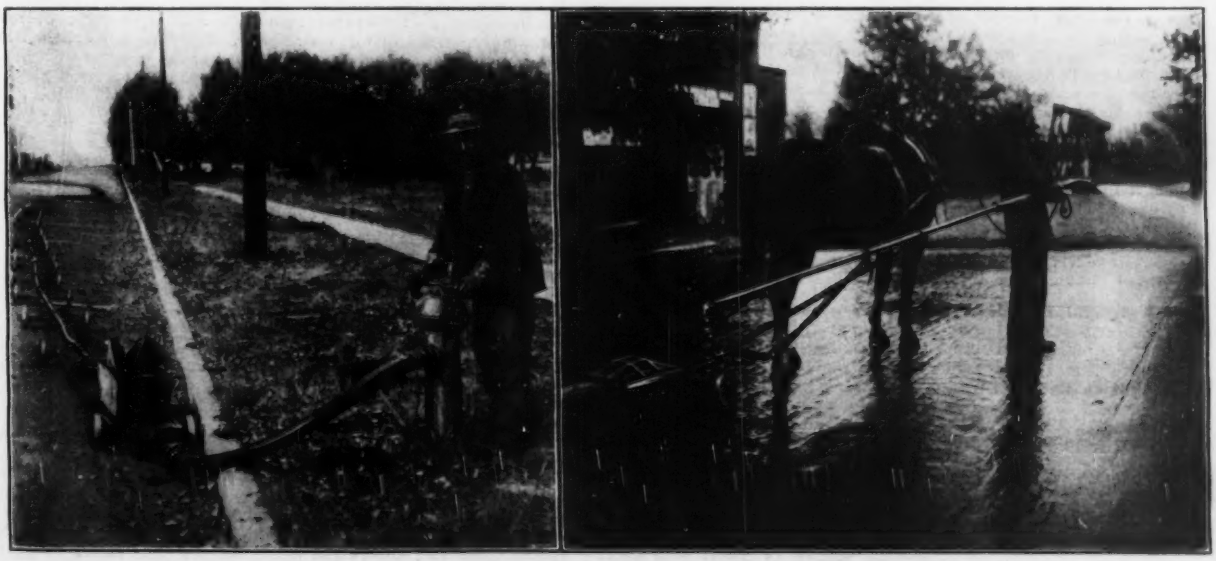
Street Flushing with Portable Water Mains

In Baker, Ore., a city of 10,000 population, a method of street flushing with a water pipe on wheels has been introduced, which is apparently new in this country, although it has been in use abroad for many years. In Baker there are fire hydrants in every block, but they are too far apart to allow more than half a block of pavement to be flushed at one time unless a hose of unwieldy length and weight is used. Therefore in place of hose, sections of 2-in. iron pipe mounted on little trucks have been adopted (see Fig. 1). The sections of pipe are connected with short pieces of hose for want of a better flexible coupling.

FIG. 3. STREET-FLUSHING DEVICE MADE BY THE BUFFALO MUNICIPAL EQUIPMENT CO.

A supply main about 500 ft. long is attached to a hydrant, and to move the device a horse is harnessed to the free end, where a swivel-jointed pipe permits the operator to turn the stream in any direction (Fig. 2). Two men are required to operate the pipe line, one being at the hydrant.

There is a patented device on the market, made by the Buffalo Municipal Equipment Co., Buffalo, N. Y., of the same general character. This is shown in Fig. 3. There



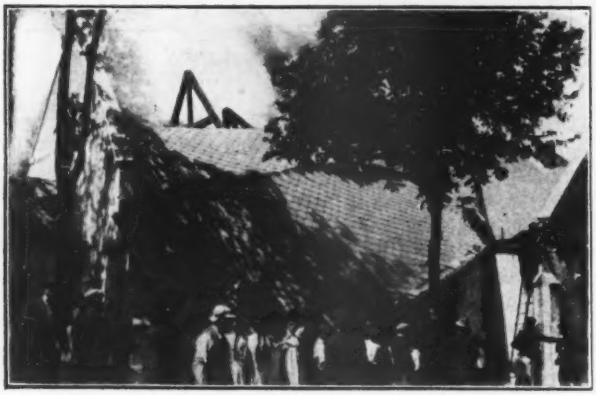
FIGS. 1 AND 2. PORTABLE WATER MAIN FOR STREET FLUSHING, BAKER, ORE.

is the same portable water pipe on little wheels, but instead of being continually dragged over the pavement the pipe is merely pulled into position in the middle of the street, where it remains while the pavement is flushed from any one of the valve openings placed at the joints. This device, unlike the first, does not obstruct traffic, as planks are placed on either side of the pipe where it crosses the trafficway, and wagons may drive over it.

FINE AGGREGATE

Laying Sewer Tiles in Cold Weather presents a difficulty in the "sweating" of the tile after being laid, causing the mortar to fall out of the joints. In building a fairly extensive sewer of segmental tile, in St. Louis, this condition was overcome by burning straw on the tile before lowering it into the ditch. This expedient is mentioned by Ben Moreell, Assistant Engineer, Board of Public Service, St. Louis.

Finding a Gas Leak with a Lighted Match seems to have just about the same effect on a church as on an ordinary building. The accompanying view shows what happened to a church in Parsons, Kan., on Sept. 16, when a plumber was

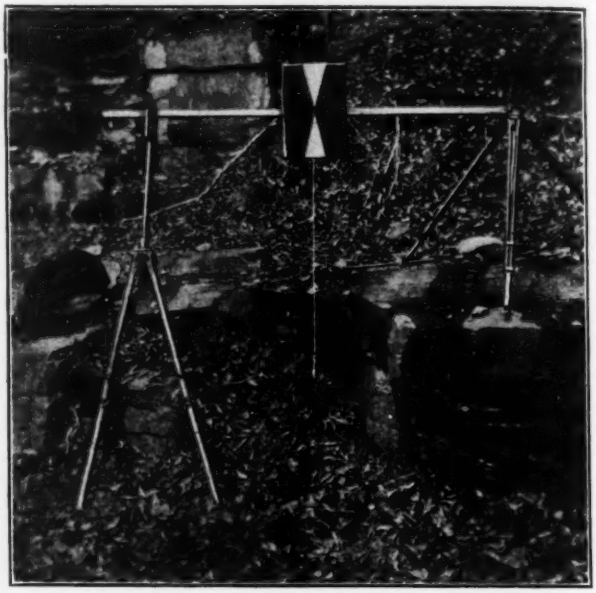


WHAT A GAS EXPLOSION DID TO A KANSAS CHURCH

searching for the source of the strong natural-gas odor that had pervaded the church cellar for some time. The building, a stuccoed brick-wall structure with a roof carried on timber trusses, was badly shattered, and the two men and a child in the cellar at the time were seriously hurt.

A Geodetic Survey of Los Angeles, Calif., is in progress, according to the annual report for the year ending June 30, 1916, of the city engineering department. The primary triangulation is practically completed and is tied into the United States Coast and Geodetic Survey triangulation net at San Pedro Mountain, Castro, San Fernando and Mount Wilson. An 8-in. Bausch & Lomb direction theodolite is used for this work, and a 150-ft. invar tape is used for base-line measurements. Atmospheric conditions have made it necessary to use heliographs for the primary work, which caused vexatious delays. The methods of the United States Coast and Geodetic Survey are being followed, and a high degree of accuracy is expected. Homer Hamlin is City Engineer, and Charles P. Cooke is field engineer in charge of the geodetic survey.

A Special Foresight for Accurate Work—The illustration shows a foresight used for accurately prolonging straight lines. It consists of a New York level rod with a special target. The rod is mounted on two tripods; it is securely clamped to the uphill tripod and rests in the fork of a stick which is wedged in the lower tripod. The target is 12x18 in., painted vermilion and white and is fastened to the regular level target. In use an equal number of shots were taken with the telescope of the transit direct and with telescope reversed, the average giving the position of the point on line. The instrument man gave signals with a large piece of orange-colored cloth. On long sights a telescope was used to see these signals. The accuracy attained depended on atmospheric conditions, length of sights, and number of shots. Under favorable conditions with a length of

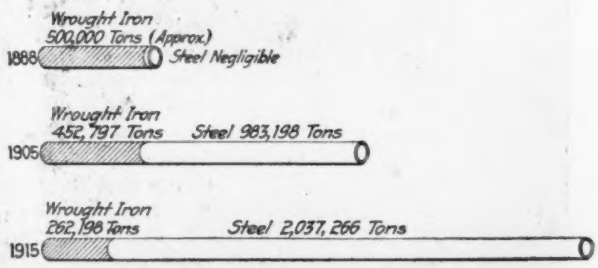


LEVEL-ROD USED AS LONG-DISTANCE FORESIGHT

foresight up to 1,500 ft., with a backsight of 600 ft. or over, averages of 10 shots, 5 with telescope direct, and 5 with telescope reversed, were less than 0.01 ft. apart; with a backsight of 800 ft. and a foresight of 3½ mi., the averages of two sets of 40 shots each were one inch apart. The apparatus can be set up in from five to ten minutes, and shots taken at the rate of 40 to 60 per hour depending on the length of sight and conditions of the atmosphere. The party consisted of a chief and one or two assistants who manipulated the foresight, an instrument man and a man to watch the backsight.—R. W. Gansmann, Browns Station, N. Y.

Board Mattresses for Revetment Work—The Blodgett Construction Co., of Kansas City, Mo., is doing about $45,000 worth of levee and revetment work on the Red River below Shreveport, La., in which the mattress work is made of 1x6-in. boards. It is practically impossible to get willows for this work and boards are specified and being used. The boards are woven together, nailed at points of contact, weighted, anchored and sunk as for ordinary mattress work. No difficulty has been experienced so far with the board mattress, and those that have been sunk are filling in a satisfactory manner.

Varied Uses of Pipe—To the engineer a pipe usually means a conductor for water, sewage, steam or gas. The application of pipe at the present day, however, is of remarkable extent. It is used in the construction of agricultural implements, automobiles, architectural ironwork and grillwork, building columns, refrigerating machinery, dry-kiln apparatus, elevator cars, wheelbarrows, work benches, ornamental gates, elevator grain spouts, safety ladders, warship masts, lightning



GROWTH OF STEEL-PIPE INDUSTRY SINCE 1888

and high-tension poles, electric-wiring conduits, railway-signal apparatus, sprinkler systems, signal towers, etc. Coincident with the extended use of tubular products has been not only increased tonnage, but also a change in material. Fifty years ago practically all the screw-joint pipe was made of wrought iron. The following diagram, made up by the National Tube Co., shows the effect on the pipe industry of the bessemer and openhearth processes of making steel.

Editorials

Signs of Clearing in Concrete-Patent Situation

In each of the last three numbers of *Engineering News* there has been reported the defeat of a suit for infringement of a reinforced-concrete structural patent. This sequence is of course mere coincidence, but the accumulation of such cases and the fact that they were all decided against the patentee are significant. The cases show a commendable though recent tendency to bring such suits to court rather than to settle them by private agreement; the decisions indicate either an intelligent conduct of the defense, hitherto rare in such suits, or else a growing understanding by the judges of the real nature of reinforced concrete. Perhaps both the counsel for defense and the judiciary have been helpfully influenced by one or two of the more recent *causes célèbres*, where clear thinking and exhaustive research have illuminated the history of this new—though in some ways quite old—structural material.

While there is no essential similarity between the three patents which were recently decided and while the issues on which they were fought were in the main different, there seems to run through each of the three decisions (rendered, it will be noticed, in widely separated districts) the same strain of reasoning. It is possible that the very next reinforced-concrete decision will be diametrically opposite to these; but reading them broadly, one would say that the judges are beginning to recognize what many engineers have long contended; that is, that the arrangement or distribution of reinforcement to meet certain peculiar ideas of the deviser is not invention and therefore not patentable.

It is possible, in view of such decisions, that sooner or later the courts will definitely set up the ruling that the essential novelty in reinforced concrete is the combination of the tensile-resisting steel with the compression-resisting concrete in such fashion as to cause the two materials to work together. This idea, of course, is quite old. It dates back to the '60's in the design of small objects such as flower pots, little boats, etc., but it dates back to the '70's even in the design of large structures.

The Brannon patent (1874) noted in the Pittsburgh case in this issue is a remarkable example of pioneer thinking. The inventor possibly did not realize the stress requirements of the combination of materials, but he most assuredly did realize its structural possibilities. The combination of metal framework with a cementitious mortar or concrete is illustrated in that patent in many ways. Hooped columns can be found there; a canal aqueduct with slab bottom and vertical sides resting on beams and columns is illustrated; and most extraordinary of all, there is a perfect facsimile of the modern hollow reinforced-concrete caisson that is cast on shore and floated out into place, there to be filled with concrete and to settle into its location as a solid pier.

Brannon, beyond all doubt, had the essential idea of reinforced concrete as a structural material. His successors devised a theory and elaborated the design; and in the mind of most of the judges recently considering the question such elaboration and amplification do not constitute invention.

It would be foolish as well as dangerous to assume that the several recent decisions against reinforced-concrete structural patents sound the death knell of all such patents. There may be many that are still legally and morally valid. But the recent decisions go far toward putting the whole question of structural patents on a more rational basis.

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The Quebec Bridge Accident and Stress Analysis

Because safety depends on strength of material and its proportioning to stress, calculation of stress is a vital element in engineering and is bound to remain so. It was vital to the accident at Quebec. The bridge rocker casting whose breaking caused the fall of the suspended span on Sept. 11 broke under circumstances where no one knew how high a stress it carried. Both the builders and the Board of Engineers assumed that the stress could not go higher than 20,000 lb. per sq.in., but they had no assurance that it might not be twice as high.

The rocker casting that broke was too weak by its very design. It was unsafe. So also were its three brother rockers. Because one of the four broke it has been called defective—it was rendered weaker than the others by some internal condition. But calling this one rocker defective does not mean that the other three were safe and adequate.

It has been learned that one of the other rockers carried nearly twice normal load, and did so without breaking. This discovery is most noteworthy. In furnishing an illustration of how a structural member may develop very high strength, it supplements the demonstration of low strength given by the failed rocker. It recalls to mind in a warning way the fact that material is inevitably variable. That is why we employ factors of safety, and why we apply large factors to materials whose variations of quality are likely to be large, and smaller factors to more uniform material.

The stress analysis presented on another page brings out the plain hard fact that the rockers at the time of failure were under very high stress. Figuring on neither the most favorable nor the most unfavorable basis of calculation, it is certain that the stress was higher than would be considered safe even in the very dependable rolled steel members of bridges. It was higher than the stress which the engineers of the Quebec bridge permitted in the rolled steel bars of the great chains by which the span was being lifted, although these had been tested so thoroughly that their large factor of safety was amply established.

Moreover, the engineers *knowingly* allowed higher stress in the rocker castings than in the chains, although (by test) the chains could not fail until 60,000-lb. stress was passed, while the ultimate strength of the rockers was entirely problematical. They allowed the high stress to be applied as a tensile stress to a thin projecting edge of a casting, where, if anywhere, a crack might have its origin. Even worse, the thin edge carried its highest stress at the root of a reëntrant right-angle corner of the casting, where the fillet had been notched to make a carefully fitted seat for a centering plate. This edge, also, was the top of the casting, where impurities often gather.

Because the specifications permitted high unit stresses, a fair degree of definiteness of stress calculation was necessary to make them safe; guessing at stresses may be good enough with very low units, but with high units it is a bit like smoking in a powder magazine. In a truss or girder, or even in a single bridge member, the degree of approximation involved in stress calculation is pretty well recognized. The question stands otherwise with parts and assemblages of the kind represented in the shoe support of the suspended span on its lifting girders.

It is the stress calculation for the parts of this support that is under scrutiny, rather than the unit stresses allowed. The units may still be safe if the method of computation is reliable. That is an "if" which the designer must meet, and meet with no hesitation or frivolous conscience. Looking at the method of calculation actually employed, however, the best that can be said for it is that it will hold true under certain conditions not definitely known.

The case of the pin and casting calculations affords a striking illustration of the old question whether a part may be stronger than the whole; whether a piece can be strengthened by cutting away some of it. The Quebec rocker would figure out to be strong enough if its longitudinal bracket arms were cut down one-half in length. Does this justify the conclusion that without such cutting down the part is also strong enough? The question is seductive, and one is tempted to answer yes, on the view that the smaller part is necessarily weaker. But in the case in hand such reasoning is a fatal error.

It happens that elsewhere all stress calculations involving loads of indeterminate distribution, like the pin and shoe reactions of the Quebec span supports, are computed according to much more conservative principles than used there. The pressures are always assumed to be uniformly distributed except where the physical conditions make likely an even more severe distribution. Thousands upon thousands of column bases and bridge shoes are in use throughout the country which were designed in this way, and none of them give any trouble. It is known that in such cases the distribution of contact pressure may be altered by deflection; but it is also known that this action may be nullified by various circumstances in the condition of the surfaces too minute to control readily.

A bald statement of the method of the calculation employed will appear harsh and unfair. Viewed superficially at least, the calculation is absurd, since it plainly tempers the wind to the shorn lamb; i.e., it adapts the load-distribution to the strength of the part, and therefore, while purporting to determine or verify the strength of the part, it does nothing of the sort. The Board's so-called check calculation presents itself as a verification of the strength of the rocker casting; but in reality it is no such verification, by any stretch of reasoning. All it shows is that, to make the shoe safe, the reaction on the base of the shoe ought to be concentrated on the middle half of the shoe length, and to make the rocker safe its reaction ought to be limited to similar ratio. It does not show that either the shoe or the rocker *is* safe. Yet, apparently, the rocker casting was approved because of some indefinite faith that the base pressure would concentrate itself in accordance with the limit which the calculation showed to be necessary. No attempt was made to compel the base pressure to respect this limit.

So the calculation appears on its face, stated without any fuller illumination. As a matter of fact, it does have some show of reason. It contains an assumption made in the design or analysis of certain kinds of structure and known from the results of practice to be safe for them, but never before applied to a rocker support of the kind here in question. The assumption is that a structure which statically might resist in different ways, but where the elastic yielding under the stresses will tend to decrease the divergence of the different methods of analysis, will be safe and adequate if any one of the methods of calculation shows stability or safe stress. This method is used widely in designing masonry arches, and has been so used for many years. It is used less obtrusively in many other cases of engineering stress calculations.

Physical recognition of deflection is, indeed, involved in the Quebec support calculation, but it does not appear on the surface and is not expressed by any direct computations of deflection. The calculation, it will be found on examining it, is at every point conducted in such a way as to be in general *qualitative* accord with the way in which the several parts deflect. Thus, the lower shoe casting, being longer than the pin which it supports, will deflect by the end rising. If at the start, therefore, reaction pressure was distributed uniformly over the base, then by the deflection of the casting the end portion will tend to rise away from the pressure and may conceivably deflect far enough upward to get no upward load at all. This latter condition is what the calculation actually assumes. So throughout the rest of the assemblage.

As to how true the calculation is quantitatively, there is no information. No check computations appear to have been made to see how much the several parts will deflect, and whether they will deflect out of contact with each other or not. It is doubtful whether such checks would have been of any value, as the controlling physical conditions are too much in doubt.

The fact is that all stress calculations dealing with indeterminate load conditions like this one rest ultimately on the conscience of the designer, and the resulting design is always more a tribute to the designer's skill and instinctive knowledge than to the merit of his stress calculation. That is the case, too, in the Quebec problem.

Simply regarded, the "stress calculation" for the Quebec rocker support is merely some formal and unimportant figuring to verify minor features of the design. It does not analyze or approve the design, but tacitly accepts the design as adequate and then deduces a few auxiliary figures from it. It is therefore chiefly significant as being an expression of complete faith in the trained eye and sound judgment of the designer who sketched out the proportions of the castings. Unfortunately that faith was not justified by the event.

Nitrogen in Activated Sludge

If a process of sewage disposal could be perfected that would yield a sludge convertible into fertilizing material at less than capital charges and operating expenses and without creating a nuisance, one of the most baffling municipal problems of the last half century would be solved. One process after another has come to the front with such a claim and gone its way without making good.

There seems to be general agreement that the new activated-sludge process of sewage treatment yields a sludge that is unusually high in nitrogen, so that it may succeed as a money maker where other processes have failed. Some of the best of the men engaged in activated-sludge studies go further and assert their belief that the sludge from this process can be rid of its very heavy water burden and marketed at a profit.

It might be supposed that long before this sewage-sludge dewatering would have been established on a sound basis. The fact is that the sludge from each new process is a law unto itself. The high nitrogen content of the sludge from the activated process is largely offset, as yet, by the difficulties experienced in handling a material that is 99% water.

The foregoing and other related facts make very timely the article on the recovery of nitrogen from sewage sludge, by William R. Copeland, and the discussion of the subject by George W. Fuller and others, presented elsewhere in this issue. The conservative yet hopeful attitude of these leaders in sewage-treatment work should inspire others to join in the study of the activated-sludge process, which presents so much, promises and yet still demands so much careful engineering, chemical and biological research. Every city with a sewage-disposal problem (with exceptions to prove the rule) may well feel that it is under obligation to itself and to other cities to take a hand in activated-sludge experimentation.

End of Septic Tank Patent

There is no longer any question as to whether the Cameron septic tank patent is alive or dead. The United States patent was granted Oct. 3, 1899, and so it has now expired, regardless of the question of whether it died with the expiration of the British patent in November, 1909.

Some important questions remain to be settled. One of these is the real effect of the see-saw decisions obtained in the Knoxville, Iowa, and Winchester, Ky., decisions. In the first of these cases the court flatly declared that the United States patent expired with the British patent. In the second, a contrary ruling was made. The holder of the patent claims that the Knoxville decision was on stipulation and affects no other city; that the Winchester ruling holds throughout the United States; and that regardless of either decision the British patent (or what was left of it after the Saratoga Springs decision) was on the process.

Another unsettled question is, What damages could the holder of the patent collect by legal process? This in turn hangs on a third and fundamental question. That is, What kind of tank (septic tank apparatus claims having been disallowed) produces the septic process? The Saratoga Springs decision, most engineers think, throws very little light on this question. Moreover, although it is some nine years since the court ordered testimony to be taken to determine the damages in the Saratoga Springs case, the amount has never been fixed. This is not all. For several years the holder of the Cameron patents vigorously pressed claims against the United States Government for the use of the septic process. The claims were contested. The next move in these claims, we understand, has now for some years rested with the holder of the patents.

The sum of the whole matter is that the real status of the Cameron septic tank patent has never yet been determined. Numerous cities, counties, states, the United States itself, have ignored the patents. So have public institutions, private corporations and individuals. And so have unnumbered engineers. Seventeen years have passed. The patents have now expired beyond all question. The Saratoga Springs decision was a barren victory for the plaintiff, so far as that village was concerned, for the plant involved has continued in use and no royalties, so far as we can learn, have ever been paid.

Oil in Engine Cylinders

We have received a report stating that a Nordberg poppet-valve superheated-steam engine in the plant of the Rockwell Manufacturing Co., at Milwaukee, in the month of July, with a total running time of 224½ hr., used only 2 gal. of cylinder oil. Computation shows that 11¾ acres of cylinder surface was lubricated for 1c., which it is claimed surpasses all previous records of economic cylinder lubrication.

There is a very general idea that economy in the operation of steam engines is measured, to some extent at least, by a low consumption of cylinder oil. It may be worth while to inquire whether this idea has any better basis than the fact that money spent for cylinder lubricants is spent outright, where one can see it, whereas the expense resulting from undue economy in the amount of cylinder oil which is used is not seen and hence is generally overlooked. The usual idea regarding the reason for the use of lubricant inside a steam-engine cylinder is that it reduces the wear and cutting of the cylinder surface and rings. In addition to this, however, if one stops to think, there can hardly be a question that it is worth while to lubricate this rubbing surface, like any other rubbing surface in machinery, merely to reduce the loss of power by friction.

The piston rings of an engine are pressed outward against the surface of the cylinder by a considerable force. The load per square inch is moderate, it is true, but the pressure exists nevertheless; and if we knew the coefficient of friction between the metal of the rings and the cylinder surface under working conditions, it could readily be computed just how much power is used up in dragging the rings over the cylinder surface. There is no room for doubt, either, that this loss of power will be greatly reduced if the rubbing surfaces are lubricated, compared with what will exist if they are dry.

Thus, even though it be true that an engine may be run with so little cylinder lubricant that 11¾ acres of cylinder surface may be swept over by the piston rings with the use of only a cent's worth of cylinder oil, the question arises whether it would not have been better economy to have used five times or ten times as much oil and gained in the value of foot-pounds of power saved, enough to pay perhaps ten times or a hundred times the additional expense for oil.

Letters to the Editor

Croton Watershed Area

Sir—I was very glad to see in an article on "Correcting the Area of the Croton Watershed," in *Engineering News* of Sept. 21, that the Department of Water-Supply, Gas and Electricity of the City of New York has at last decided to adopt, as the official figure for the area of the Croton watershed above the new Croton dam, 375 sq.mi., instead of 360 sq.mi., the figure hitherto given in all official reports. The very careful mathematical calculations upon which the former figure is based were made more than 10 years ago by J. Genthon, one of the engineers of the Aqueduct Commission. In preparing the final report of this commission, covering the years 1895 to 1907, I tried very hard to get the correct area of the Croton watershed, mentioned above, adopted, but the then chief engineer refused to do so, on the ground that the published tables of the rainfall and runoff of the Croton watershed had been generally accepted and that he did not wish to cast any doubts on their correctness.

In a recent water-power case I had occasion to use these tables; and when their value was attacked by the experts of the other side, I was unable to maintain that they were accurate, as I knew that they were not, in respect to the area of the watershed.

To show how reluctant some officials are to make corrections when errors are pointed out, I will mention the curious fact that, while the contents of the reservoirs of the Croton water-works, built prior to 1842, were given in Imperial gallons and those of later storage basins were stated in United States gallons, they were added together, in getting the reservoir capacity of the works, without making any corrections for the different units employed. Thus the contents of Croton Lake were given as 500,000,000 gal. when they were really 600,000,000 U. S. gal. When I drew the attention of the chief engineer of the Water Department to this matter, he was unwilling to change the figures, because he did not wish to make any changes from former reports.

Of course, it will involve considerable work to recalculate the runoff of the Croton watershed; but when that is done, the Croton rainfall and runoff tables will be accurate and valuable, which they are not in their present incorrect state.

E. WEGMANN,
Consulting Engineer.

Park Row Building, New York City, Sept. 22, 1916.

Sir—I have read with gratification your article in your last issue, entitled "Correcting the Area of the Croton Watershed." In 1888, when the late William E. Worthen was acting as consulting engineer, on his recommendation the writer was employed by the Aqueduct Commission to make a careful resurvey of the entire Croton watershed, and the work was prosecuted by the firm of Vermeule & Bien.

On the completion of this survey in 1889 a careful geodetic computation of the area was made by me in just the manner described by Mr. Brush as having been pursued in 1909. The results have been given by Mr. Brush as of that date.

It will be remembered, however, that the Aqueduct Commission and the Department of Water-Supply were distinct organizations at that time. The records of rainfall and runoff were kept by the department, which continued to use 338.8 sq.mi. The writer did not have direct knowledge of the later inside history of this matter, but observed that the old incorrect figures continued to be used, the result being that all precipitation records given in inches in the catchment or in second-feet per square mile, even those contained in the careful computation made by Mr. Freeman, were too large to the extent of 4.4%.

In my "Report on Water-Supply," made to the state geologist of New Jersey in 1894 (page 53) I gave the correct area above the old Croton dam to be 353.1 sq.mi. Again in my report of 1899 (see page 146, "Annual Report of the State Geologist of New Jersey"), I stated that the survey made by me showed the area to be 353 sq.mi.

Once, when attempting to correct the error publicly, I was severely chided for my presumption by an eminent engineer, who assumed I was reflecting on the late Alphonse Fteley, whereas he and Mr. Worthen had stood sponsor for the survey made by me. Being very busy with other matters, I did not enter into an extended controversy, concluding that truth would be strong enough to take care of itself, but the sequel proves that it has needed the help of Mr. Brush.

The fact that the original measurement, made by plane survey, agrees closely with the geodetic computation indicates merely a balancing of errors.

C. C. VERMEULE.

220 Broadway, New York City, Sept. 26, 1916.

NOTES AND QUERIES

The Bridge-Erection Disaster at Quebec is the subject of an inquiry by S. R. B., Dyersburg, Tenn., who writes:

Was the loss complete so far as the material and construction were concerned, or was insurance carried for protection, in case of accident to the span?

According to our information, the contractors had marine insurance on the suspended span during the time while it was floating on the scows. This insurance terminated, however, when the feat was successfully accomplished of transferring the load from the scows to the lifting chains. The loss of the span therefore is not covered by insurance.

Screens for a Water-Works Intake are desired by a correspondent in Michigan, who writes: "We are figuring on building an intake crib in a shallow river for a 24-in. suction line feeding our cold well. We want to get hold of three intake screens, each one capable of supplying the line with water. The intake fittings should be so arranged that they may be closed, screen removed and cleaned, then reopened. Also in case we wish to, all three may be closed and the intake pumped out for purposes of repair or inspection. While it is quite a simple matter to design such a fitting, we felt that there are surely some standard designs on the market, hence our appeal for information as to the manufacturers."

Nitrogen from Sewer Sludge Plain and Activated*

By William R. Copeland†

SYNOPSIS—A review of the possibilities and difficulties of recovering nitrogen from sewage sludge, with special reference to the activated-sludge studies at Milwaukee. There follows an abstract of some discussion by George W. Fuller and other engineers.

The answer to the question as to whether it is or is not practicable to recover the nitrogen in sewage and sewage sludge will depend upon three factors: (1) The amount of nitrogen contained; (2) the cost of recovering and disposing of the nitrogen; (3) the market value of the nitrogen.

Recovery of nitrogen, from the standpoint of this paper, has to do principally with the nitrogen in suspension, because that is the portion which appears in the greatest quantity in the sludge. The total obtained will vary both with the treatment process used and with the volume contained by the raw sewage (see Table 1).

TABLE 1. COMPOSITION OF DRY AND 10% MOISTURE SEWAGE SLUDGE

On the Basis of Dry Sludge*

Source of Sample	Sludge Obtained from	% of Nitrogen
Frankfurt-am-Main	Plain sedimentation	2.85
Columbus, Ohio	Septic tank	1.40
Essen	Imhoff tank	1.22
Philadelphia	Imhoff tank	1.20
Worcester, Mass.	Chemical precipitation	2.77
Sludge Computed on Basis of 10% Moisture†		
Brooklyn (Williamsburg)	Dickson (yeast) process.	1.4
Columbus testing station	Grit-chamber sludge	1.2
	Plain sedimentation tank	1.6
Philadelphia testing station	Plain sedimentation tank	1.2
Cleveland testing station	Plain sedimentation	1.4
	Septic tank	1.3
	Imhoff tank	1.2
Gloversville testing station.	Plain sedimentation	2.3
	Septic tank	2.2
Worcester, M. & E., Vol. III.	Plain sedimentation	2.7
	Septic tank	2.7
Atlanta	Imhoff tank	1.5

*From Vol. 2, Metcalf & Eddy's "American Sewerage Practice." †Data compiled by J. R. McClintock, Consulting Engineer, New York City.

The gist of the data given in these tables is that the sludge which has been obtained heretofore by the best known processes of sewage treatment contained from 1.2 to 3% of nitrogen. These figures are low and show that the sludge did not possess as much nitrogen as the amount contained by the raw sewage would lead us to expect. This condition may be explained by the fact that a large share of the colloidal matter carried by the sewage ran out in the tank effluent and took nitrogen with it; or in the case of chemical precipitation works the lime added drove nitrogen off in the form of ammonia and diluted the portion remaining by increasing the amount of inert mineral matter. Moreover, various authors state that from 10 to 60% of the volume of the solids deposited by sewage in the sludge-digestion chambers of Imhoff tanks and other forms of septic tanks is converted into soluble or gaseous form.

Much of the albuminoid ammonia is thus changed into free ammonia and free nitrogen, which escape in the liquor or bubble out at the gas vents.

Within the last two years, however, a new method of sewage purification by the so-called "activated sludge" process has been tried out in various cities of America and England. One of the distinctive features of this process is that the colloidal and suspended matters of the sewage are collected in the sludge. If this is not reaërated or overaërated, the solids are not liquefied to such a large degree as they are in septic tanks, and therefore the nitrogen does not escape.

For example, the digested sludge accumulates in Imhoff tanks at a rate of from 4 to 10 cu.yd. per million gallons of sewage treated, whereas by the activated-sludge process 20 to 80 yd. or more may be deposited in the settling tanks, varying widely, of course, with the strength of the sewage and the water content of the sludge.

The Milwaukee sewage-testing station carried on a series of experiments during the summer of 1915 where the city sewage was treated by the Imhoff and activated-sludge processes simultaneously (see Table 2).

TABLE 2. ANALYSES OF MILWAUKEE CITY SEWAGE BEFORE AND AFTER TREATMENT

By Imhoff Tank and by Activated Sludge

Period of Test, 1915	Source of Sample	Parts per Million: Suspended Matter	Nitrogen as Ammonia: Free	Nitrogen as Ammonia: Albuminoid	Nitrogen as: Organic Nitrogen	Nitrogen as: Nitrite	Nitrogen as: Nitrate
August	Sewage	253	14.6	7.88	29	0.15	0.13
	Imhoff effluent	105	16.2	6.10	27	0.19	0.13
	Activated-sludge effluent	14	3.8	3.19	6	0.29	6.00
September	Sewage	300	13.5	8.81	29	0.25	0.14
	Imhoff effluent	116	15.4	7.10	27	0.12	0.09
	Activated-sludge effluent	8	5.7	2.22	9	0.24	5.01

Samples of digested sludge from the Imhoff tank and of the fresh activated sludge were also collected and analyzed in August and September (see Table 3). While it is not correct to say that these sludges represent all of the raw sewage passed through these tanks during August and September, it is fair to assume that they are typical of the sludge that was being produced by those processes at that season of the year.

TABLE 3. ANALYSES OF SAMPLES OF IMHOFF AND ACTIVATED SLUDGES OBTAINED FROM MILWAUKEE SEWAGE

Date, 1915	Source of Sample	Nitrogen Reported as NH_3 on a Basis of Sludge Dried to 10% of Moisture
August	Imhoff sludge	2.87
		3.82
		5.71
	Activated sludge	4.97
		7.04
September	Imhoff sludge	3.88
	Activated sludge	8.69
		9.00

The data given in Table 2 show some interesting facts. For example, the Imhoff effluent contained on an average more than 100 parts per million of suspended matter, whereas the effluent from the activated-sludge process contained only about 10 parts per million; the Imhoff effluent contained more free ammonia than the raw sewage, whereas the activated-sludge effluent contained only one-third as much. The Imhoff effluent contained almost

*Slightly condensed from a paper entitled "Is the Recovery of the Nitrogen in Sewage Sludge Practicable?" read before the Division of Water, Sewage and Sanitation of the American Chemical Society, Sept. 28, 1916. An abstract of the discussion follows.

†Chemist in Charge, Sewage Testing Station, Milwaukee, Wis.

as much albuminoid ammonia as the raw sewage, whereas the activated-sludge effluent contained only about one-third as much. The Imhoff effluent contained almost as much organic nitrogen as the raw sewage, whereas the activated sludge contained only one-third as much.

What became of the nitrogen carried by the sewage? Evidently most of the nitrogen in the sewage treated by the Imhoff tank passed out in the suspended and colloidal matters carried by the effluent. The activated-sludge process, on the other hand, converted the free ammonia into nitrate and stored up the undissolved albuminoid ammonia and organic nitrogen, as indicated by the large amount of nitrate in the effluent and high nitrogen content of the activated sludge.

In short, analyses of this material when dry show that activated sludge contains from 4 to 4½% of nitrogen, and sludge from certain industrial plants, such as packing houses, may carry even more.

When it comes to recovering this nitrogen, however, we meet with a serious difficulty, because as the sludge gathers in the settling tanks it contains from 98 to 99% of moisture and the bulk of this water must be removed before the dry material can be sold for fertilizer.

The best information now available points to a combination of settling and decantation as a preliminary dewatering process. By this means the water will be cut down from about 99 to 96%. On passing the concentrated residue through a pressure filter the moisture can be cut down to 75%. The press cake can be dewatered in a drier to 10% of moisture or less. More than 30 samples of activated sludge have been dewatered by sedimentation, decantation and pressing at Milwaukee.

It is an interesting and notable fact that two different types of press can handle the settled sludge without requiring the addition of lime. The sludge is not as gummy as was expected, and it presses fairly easily down to 75% of moisture.

In order to try out the feasibility of further dewatering the sludge four samples of the press cake were sent to fertilizer plants and dried there on a commercial scale. Three of these tests were made in a steam-jacketed (indirect-heat) drier and one in a semidirect-heat drier. In each case the tests proved to be successful from three standpoints: (1) The sludge dried readily to a satisfactory mechanical condition; (2) the processes did not require much power; (3) little nitrogen, if any, was driven off or lost by drying. From the mechanical standpoint, therefore, the recovery of nitrogen in sewage sludge is practicable.

With regard to the question of cost, however, the situation at the time of writing is not so clear. The pieces of apparatus used for settling the raw sludge and drying the press cake were not designed to handle activated sludge in the most economical manner, but were requisitioned as being the best commercial apparatus available at the time.

By comparing the behavior of activated sludge with such matters as packing-house tankage I estimate that this sludge can be dewatered so that the recovery of the nitrogen in it will probably cost, upon present evidence, about $8 to $12 per ton of material containing 10% of moisture, depending upon a variety of local factors. These figures are intended to cover interest charges, depreciation, repairs and renewals, and a liberal provision for labor and fuel, as well as the cost of resettling and decanting of the water of the original sludge, and expenses for handling, freighting and marketing the finished product. Obviously, the total cost per ton will be somewhat more in the case of a small plant than for a large one. For a very large plant, where fuel and labor are relatively cheap, it is possible that further experience will reduce the cost below the lower limit in the range here given.

Analyses of dried samples of sludge are given in Table 4. They indicate that dry activated sludge (basis of 10% moisture) will contain 4.6 to 5% of nitrogen figured as ammonia and 0.6 to 0.7% of available phosphoric acid. In addition to this our data show that the dry product contains about ¼ to ½% of potash and from 3 to 4% of fatty material. At present prices the nitrogen is worth $2.50 per unit (or per cent.). In normal times this nitrogen would be worth about $2 per unit. The phosphoric acid is worth about 50c.; and the potash may be worth something in the future, although the best that can be said of it at present is that it will assure for the fertilizer a more ready sale.

TABLE 4. ANALYSES OF COMMERCIALLY DRIED ACTIVATED SLUDGE, MILWAUKEE
Basis of 10% Moisture*

Sample No.	Character of Drier	% of Nitrogen as Ammonia	% of Available Phosphoric Acid
1	Semidirect heat	4.36	0.70
2	Indirect heat	4.76	0.81
3	Indirect heat	4.56	0.47
4	Indirect heat	5.06	0.39
	Average of four samples	4.68	0.57

*Additional analyses for percentage of nitrogen as ammonia on the 10% moisture basis showed the following results, the dates being dates samples were collected: May 3, 1916, 5.74; June 20, 1916, 4.65; June 13, 1916, 4.88; June 14, 1916, 4.92; June 16, 1916, 5.01.

The fat present in the Milwaukee sludge is negligible. It would not pay to recover the fat, nor will the fat injure the selling qualities of the dried sludge.

Summary

Summing up the whole situation, then, we see that the dried sludge has a market value upon present figures of $9 to $15 per ton of material containing 10% moisture. The total cost of getting this product and placing it on the market will probably run from $8 to $12 commercially per dry ton, depending upon local conditions. For large plants this cost may possibly be reduced as a result of further experience.

The activated sludge containing 4% or more of nitrogen is much nearer a commercial possibility than the sludges obtained by the older methods of treatment, such as chemical precipitation, septic tanks, or the Imhoff process, which the data given in Table 1 indicate to contain only 1½ to 3% of nitrogen.

In case the question arises as to the possibility of finding a market for the dried activated sludge it should be added that raw materials containing nitrogen, phosphoric acid and potash are capable of being worked up readily as a base for making high-grade fertilizers; and as they are not very plentiful, they are in good demand.

Presumably, however, large cities, such as New York, Chicago and others, by installing this activated-sludge process would produce so much raw material of this character that the product would have to be parceled out among a number of manufacturers. It is even possible that the production might be sufficient to reduce the price. However, the dried sludge is a good fertilizer just as it stands and contains enough value to pay for sale and distribution in quite a large local market.

Discussion of Copeland's Paper on Nitrogen Recovery

By George W. Fuller*

Experience showed years ago that plain sedimentation removes about one-third of the total organic matter in ordinary sewages and that chemical precipitation removes about one-half. That which is removed by these tankage treatments normally appears in the accumulated sludge. The balance passes out of the tank with the effluent. Table 2 of Mr. Copeland's paper shows that with the activated-sludge method the removal of organic matter is in the vicinity of 70%. This seems perfectly logical in comparison with the results of plain sedimentation, owing to the fact that the activated-sludge treatment removes colloids and other nonsettling organic matters.

When we consider the nitrogen content of Imhoff tank sludge, and the same would be roughly true for sludge of single-story septic tanks, it is necessary to recognize clearly, as pointed out by Mr. Copeland, that there is a material reduction in organic matter, due to the liquefaction and ultimate gasification of organic matters in a form permitting their direct release into the atmosphere. Obviously, septicization must mean a loss of the nitrogen content and hence of the fertilizing value of sludge.

On the other hand, activated sludge, reinforced with the nitrogen content of colloidal and nonsettling matters, is not only spared the loss of nitrogen, but is actually able to show a substantial gain in nitrogen as a result of containing some of the more or less oxidized nitrogen. The removal of free ammonia (Table 2 of Mr. Copeland's paper) is quite striking. Part of it doubtless passes to nitrates, but it would be interesting to know what portion of it becomes available for fertilizing purposes by adherence to the solid sludge as dried.

Nitrogen Content of Dry Activated Sludge

Figured on a commercially dry basis (10% moisture), Mr. Copeland's average figures show a nitrogen content that may be compared with some other data from activated-sludge tests as follows:

	% Nitrogen
Milwaukee data (Copeland)	4.40
Manchester, England (Arden)	4.60
Salford, England (Melling)	3.75
Urbana, Ill. (Bartow)	3.5 to 6.4
Armour & Co. (Noble)	4.6
English range (Fowler)	4.0 to 6.0

These figures are expressed in terms of nitrogen and not of ammonia, as seems to be the custom in speaking of the composition of tankage from garbage works. Nitrogen is only 82% of the ammonia content. Many published analyses refer to absolutely dry sludge, whereas most of the recent data refer to commercially dry sludge with 10% of moisture.

From a commercial standpoint it is highly important to know whether the analyzed samples of sludge are representative or not of the annual output of the plant. Where sewage from a separate system of sewers is treated, this is not so vital a matter as in the instance of the sewage from combined sewers, where the amount of mineral detritus is bound to vary materially. Obviously mineral matter dilutes the organic sludge with inert material which, pound for pound, costs as much to dry and prepare for the fertilizer trade as in the case of organic matter free of street wash and industrial wastes.

Dewatering in Three Stages

It is an altogether different matter to dewater activated sludge obtained from a settling tank in a flocculent condition and mixed with 99% of water than it is to deal with Imhoff sludge containing 87% of water and mixed with gas, so distributed as to cause practically all of the solid matters to rise and allow the withdrawal of subnatant water.

*Consulting Engineer, 170 Broadway, New York City.

Clearly, the first step is to resettle and remove by decantation as much surface water as practicable, as described by Mr. Copeland. This, he says, at Milwaukee allows them to get sludge of about 96% water content. To carry this resettling far seems to be impracticable, owing, among other things, to the fact that the activated sludge after settling and during storage seems to undergo putrefaction within a period of 24 hr. or less. Further aëration for 4 or 5 days would make this settled sludge nonputrescible, but this treatment results in the consumption of a substantial portion of the available nitrogen.

The real problem is to dewater this resettled product. The speaker has given a good deal of attention to this matter recently and offers comments concerning the two latter stages of dewatering, as follows:

Dickson Process for Second Dewatering Stage

Mr. Copeland describes the use of Worthington presses for reducing the water content from about 96 to 77%. Based on general experience, it will cost for a fairly sizable plant about $3 per ton of absolutely dry solids for pressing. For commercially dry sludge with 10% moisture this figure would be about $2.70 per ton. This makes no allowances for interest, depreciation or overhead charges.

It occurs to the speaker that perhaps the Dickson yeast fermentation process might accomplish this result at a much lower figure, although he is not prepared to give any cost data at present. Within the past few months he has had opportunity to investigate, in behalf of New York bankers, a test plant built in Brooklyn under the eastern end of the Williamsburg Bridge for treating about 500,000 gal. of sewage per 24 hr., according to the Dickson process which was originally installed at Dublin, Ireland. The sewage is subjected to plain sedimentation in hopper-bottom tanks from which the sludge is removed at intervals and a portion of the water removed by further sedimentation. This sludge, with 92 to 96% of water, is mixed with about ½% of brewers' yeast and allowed to ferment for about 24 hr. in long, narrow, round-bottom, sloping tanks, which are jacketed and kept heated to about 90°. Anaërobic bacteria decompose the yeast cells and cause the sludge to become so mixed with entrained gases that the solid matters rise to the top in a manner similar to that noted with Imhoff tank sludge, and a fairly clear subnatant water is removed through a perforated pipe at the bottom of the tank. The water content of the remaining sludge averaged about 80%, according to analyses made by Hill and Ferguson, but some samples showed 75%, which, with improved devices could probably be obtained regularly.

No activated sludge has been treated at this plant, which has been shut down for several weeks pending changes. It is proposed to treat activated sludge as soon as material may be obtained from the Brooklyn testing station. So far as known, there appears to be no reason why activated sludge cannot be dewatered by the yeast fermentation process in a manner similar to that experienced with the sludge of plain sedimentation tanks, as is being installed on a large scale by Mr. Watson at Birmingham, England.

Sludge-Drying Possibilities

Mr. Copeland refers to both indirect-steam driers and direct-heat driers, with results that promise practical success for reducing the water content from about 75 to 10%. Much weight should be attached to the fact that success

has attended the drying of wet products in other industries, such as garbage tankage and refuse from stockyards, packing plants, etc. To drive off 4 to 6 lb. of water with 1 lb. of coal seems to be attainable with the devices now on the market. Some manufacturers seem willing to guarantee a removal of 10 lb. of water for 1 lb. of coal. A test guarantee of 8 lb. evaporation seems reasonable, according to the conclusion arrived at in the office of the speaker, but in practice it would probably be wise to make some allowance for waste heat, which is characteristic of all plants of this general character.

Whether or not it would be worth while to use an indirect-steam drier for removing a portion of the water and then finish the drying in a direct-heat type of machine is a point perhaps worthy of discussion and upon which the writer has reached no final conclusion.

Other Related Discussion

Sewage-treatment processes, said R. S. Weston, come and go, giving satisfactory effluents, but the sludge problem remains. Driers seem practicable, presses doubtful. The speaker is coming to the conclusion that all the dewatering must be done in one process.

In the course of a paper on activated sludge, presented at the same session, George T. Hammond, Brooklyn, N. Y., made some remarks pertinent to this discussion. Although dewatering apparatus, he said, has long been used in many industries, it has yet to be adapted to sewage sludge and particularly to activated sludge. The possibilities of a partial dewatering by long-continued aëration of activated sludge in the lower chamber of a tank of the Imhoff type are being studied at Brooklyn with good promise. The water is withdrawn from the upper chamber. As the process is continued the volume of sludge to be reaërated grows less.

In concluding the discussion Mr. Fuller said that Mr. Weston's ideas on drying were good, but that drying would probably cost more than pressing.

Another Reinforced-Concrete Patent Decision

By Edward Godfrey*

A patent suit has just been decided which, if it had been successful for the patent owner, would have meant more to the reinforced-concrete industry than all the other patent cases rolled together and multiplied by a large figure. It was decided against the patent owner.

The Schenley High School of Pittsburgh is a large million-dollar structure just being finished for occupancy. The construction is a combination of steel columns, some steel and some reinforced-concrete girders and beams, and reinforced-concrete slabs, including rib and tile floors for the wider spans. There is also a counterfort retaining wall.

The writer made a complete review and re-design of the structural work. One act of this re-design was to throw out many tons of stirrups. Not a shear member was left. Diagonal tension was provided for in all beams and girders by bending up main tension members and either bending them down again over the supports for anchorage or running them into the next girder or beam to serve the double purpose of anchorage and tension reinforcement across the support for the next beam. By one of those ironies of fate this design, that had been completely swept of all loose shear members, was the target at which a patent owner aimed, whose main claims are for unattached shear rods.

*Monongahela Bank Building, Pittsburgh, Penn.

Claims of the Patentee

Frederick Melber, to whom the United States Patent Office granted patents Nos. 660, 518 and 672, 175, in 1900 and 1901, respectively, entered suit against the contractors, Thompson-Starrett Co., the School Board, and Edward Stolz, the Architect of the Schenley High School, for infringement of his patents. Sample claims of his patents are the following:

> In cement or concrete construction metal reinforcing bars, unattached at their ends to other metal reinforcing bars, imbedded therein transversely to the calculated shearing strains, and other metal reinforcing bars imbedded in said construction to resist the tension strains. . . .
>
> An anchor for cement or concrete construction consisting of a member imbedded in the soil in line with the direction of the thrust to be counteracted and a rod or rods fixed to said member and partially imbedded in the base of said construction. . . .
>
> In cement or concrete construction, two or more girders; metal rods imbedded in said girders along the lines of the tension strains; other metal rods, unattached at their ends, imbedded in said girders transversely to the shearing strains, and floor slabs connecting said girders. . . .
>
> In cement or concrete construction, a wall of cement or concrete; brackets attached to said wall and metal reinforcing rods imbedded in said construction.

If these claims mean what they appear to mean on their face, every building having unattached stirrups, every beam and slab building having like shear members in it, every piece of construction that is anchored to a base by bolts or rods, every counterforted retaining wall built in the last sixteen years would have to pay tribute to Frederick Melber.

This case is illuminating in many ways. It shows what may happen to the innocent bystander in the person of an unoffending contractor when a patent suit bomb explodes. These contractors were put to the expense of thousands of dollars because the United States Patent Office did some clumsy work in granting a patent to a man for things that were described, and even patented in the United States, long before he made application for his patent.

Such things ought not to be. The Patent Office ought to be compelled to invalidate a patent when it can be shown, by interested persons, by citing references and by argument, that there is no novelty or no invention exhibited in the specifications or the claims. The only expense this should place on the interested persons should be that of their own search or possibly a nominal fee to prevent incessant opening of cases for such arguments. It should be done by the Patent Office examiners and not by the slow and cumbersome methods of the courts.

It will no doubt be instructive and useful information for readers of this journal to record here the anticipations of Melber's alleged invention, as brought out in this suit, also to state some of the history of the case.

It is doubtful if one reinforced-concrete engineer in a thousand ever heard of Melber and his patent, though they have been infringing his patent claims for nearly the whole life of his patents, which expire in a year or two.

The wording of the Melber patent and the testimony of Mr. Melber, who was his own expert witness, all show clearly that he has the primitive idea that steel rods

in concrete can act effectively to take shear between successive layers of concrete. In his testimony he was asked, "Did you ever hear of what is called diagonal tension in a beam?" His answer was: "That is wrong. Whoever says that there is diagonal tension doesn't know anything." The patent drawings show short, loose shear members. Though the bent-up rods in the high school acted to take diagonal tension and were not designed for shear, and though they acted at the same time as main tension reinforcement, both in the middle of the beams and over the supports, Melber claimed that they filled his description of unattached shear members because, forsooth, there were two ends somewhere to the long rods, that were not attached to anything.

A thing that no doubt gave much hope to the complainant was shown in one of his exhibits. A sketch from the contract plans was taken which showed a header supporting rib and tile construction. In each rib was shown a vertical line indicating in foreshortened view the long reinforcing bent-up rod. The tiles were indicated by two diagonal lines in the ordinary conventional way. Of course the tension rod was shown in the header. This view, in the "Exhibit" had the vertical and the diagonal lines marked "shear rods." Of course these lines did not represent shear rods, but this blunder probably had much to do with the bringing of the suit and the large needless expense on unoffending parties.

Anticipating Patents Cited

One of the patents that anticipate Melber's is the English Patent No. 28, granted to Hyatt in 1877. This shows clearly steel reinforcement used for tension near the bottom of a concrete beam, also compression bars near the top; also a tension bar bent up near the ends of beam; also flat tension bars having upright bolts or pins through holes in the flats, the forerunner of the stirrup, which many consider as a member that carries the increment of horizontal shear to the tension bar.

Another anticipation is in U. S. Patent No. 206,112, Hyatt, 1878. Reinforced-concrete beams and slabs are shown with straight tension bars near the bottom, also the combination of beam and slab.

In English Patent No. 2,128, granted to Brannon in 1874, reinforced concrete, among other things, is described. Steel reinforcement in cement concrete is one of the things covered by this patent. Brannon states, "I also dispose the great strength of the tension work in the plane in which tension forces act in the structure." Melber goes to great length to describe his construction as so reinforced that tension steel is placed in the exact position of the resultant tension in the concrete. Brannon shows a counterforted retaining wall among the different classes of construction, reinforced throughout with steel. Brannon also shows floor slabs and girders combined.

It is interesting to note in passing that Brannon describes what is practically a hooped column, for it has a steel mesh near the surface; also that Hyatt shows a real hooped column, the hooping being flats in circular shape, the wider dimension being horizontal; upright rods pass through holes in the flats. Thus the hooped column, which some claim to be covered by a patent granted in this century, was anticipated back in the '70's.

U. S. Patent No. 472,277, granted to Sickels in 1892, shows bridge piers anchored by means of a well extending below the pier and a rod in the well, which rod extends up into the pier, the well being filled with concrete. This is precisely the kind of construction used in the Schenley High School. The "wells" were holes made by driving steel shells into the ground (Raymond piles). Rods were let down into these and concrete was poured around the rods. A short portion of the rod extended up into the footing.

U. S. Patent No. 590,690, Small, 1897, shows anchorage of an arch at the abutment, similar to Melber's patent No. 672,175.

U. S. Patent No. 607,223, De Man, 1898, shows reinforcement somewhat similar to the Schenley High School construction, though some of his features were not made use of.

U. S. Patent Nos. 611,907 and 611,908, Hennebique, Oct. 4, 1898, shows construction similar to that of the Schenley High School, though the stirrups shown by him were entirely omitted in that building.

U. S. Patent No. 611,909, Hennebique, Oct. 4, 1898, shows a pile having upright rods, which rods project above the top of the pile. This is similar to the high school construction and anticipates Melber.

The *Deutsche Bauzeitung* of Dec. 15, 1894, p. 621, describes and illustrates a test made in 1893 on a wall with a vertical and a horizontal slab joined by triangular brackets as counterforts, practically identical in shape with the retaining wall used in the Schenley High School, and with reinforcing rods used in the bracket, all of which is claimed as an invention by Melber. Furthermore, this same wall had an anchor into the ground similar to that claimed by Melber. An L-shaped wall on the same page is also anchored similarly to Melber's claim.

Judge's Decision Against Patent

Judge J. Orr in his opinion, in which he declares the patent invalid, pointed out the fact that while earlier inventors made no attempt to locate the exact position of reinforcing rods nor to reason out just why rods are placed in certain positions, the inclusion of such reasoning and explanation in Melber's specifications does not constitute invention and does not give him a patent right on these earlier inventions. To quote Judge Orr, "A man is not entitled to a patent for a structure which is old just because he determines the reason why the structure should be used. Why straw was necessary for the making of bricks by the Egyptians or why cow hair was used in mortar where large surfaces were to be covered, may not have been scientifically observed by those who first engaged in the practices, but none the less their anticipations should prevent the granting of a patent to one who is able for the first time to scientifically state the reason for such uses."

Concrete Electric Conduits are coming into extensive use, reported the Committee on Underground Construction of the National Electric Light Association at the recent convention in Chicago. Single-duct pipe is used, with the following standard dimensions: Length, 5 ft.; internal diameter, 3½ in.; wall thickness, ⅝ in. Split bends and straight lengths are made as specials. When laid, adjacent lengths are held in place by a sheet-iron band fitting over the ends. A minimum of 1 in. of concrete is laid between ducts and between layers. It is reported that cable burnouts are not communicated to other ducts, as often is the case with vitrified-tile conduit. The cost is about the same as for clay-tile construction.

News of the Engineering World

Creosoted Timber Floor Fire Racks Missouri Bridge

The floor of the highway bridge over the Missouri River at St. Charles, Mo., caught fire on Sept. 26 and practically the whole floor of the bridge and the east approach trestle were destroyed. This bridge was built in 1903 to carry a single-track interurban line and a highway. It consists of four main truss spans, three of which are 416 ft. long and one 300 ft. long, approached on the east end by a 160-ft. deck span (Fig. 2) and a timber trestle and on the west end by a timber trestle. The main line of the Missouri, Kansas & Texas R.R. passes under the west end of the bridge just outside of the last pier.

The floor system consisted of 4x16-in. timber stringers spanning the floor-beams. On top of these stringers were 6x8-in. cross-ties 20 ft. long on which were laid 3x10-in. longitudinal planking with about 2-in. open spaces and a diagonal plank floor. Two years ago the top floor planks were renewed and the floor was relaid with creosoted timber.

About five o'clock in the afternoon of Sept. 26 fire was discovered in the wooden floor system over the tracks of the railroad at the west end of the bridge. In spite of

FIG. 1. LOOKING AT THE SOUTH SIDE OF THE ST. CHARLES BRIDGE DURING THE PROGRESS OF THE FLOOR FIRE

FIG. 2. LOOKING WEST ACROSS THE RIVER AFTER THE FIRE ON THE BRIDGE
Note tipped truss shoe in left foreground at west end of bridge

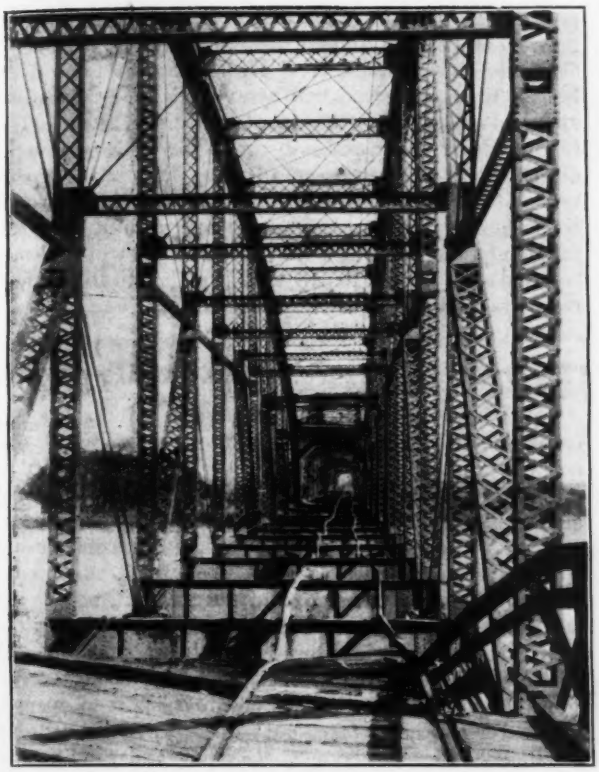


FIG. 3. THROUGH THE TRUSSES AFTER THE FIRE
Buckling of the north posts and diagonals may be noted on the left-hand side of the bridge

the efforts of the local fire department and some equipment from St. Louis, which is 20 mi. away, it was apparently impossible to stop the flames. The wind at this time was blowing steadily from the southwest and drove the flames very strongly against the north truss. The fire was also carried across the bridge by the diagonal winds and by ten o'clock that night the whole floor system, with the exception of a short piece at the west end, and the whole of the east timber trestle were completely destroyed. It is supposed that the fire caught from a spark from a locomotive under the bridge which lodged in some dry rot material at the corners of the old timber stringers and was whipped up by the wind until the creosoted floor took fire.

An examination of the damage is being made by Ira G. Hedrick, the consulting engineer of the original construction, but Mr. Hedrick has not as yet prepared an estimate of the cost of replacement. The accompanying views show some of the damage. It will be seen that the wooden structure is entirely gone and that the steelwork is quite seriously damaged in places. The south truss is apparently uninjured, but the bottom chords in the lower portion of the uprights of the north truss, which was subject to the more severe heat, are badly warped, some of them being bent to a letter S. Where the circles are on Fig. 4 the most serious buckling may be noted.

An interesting feature of the effect on the steelwork is the fact that the bottom chord members are also warped, and the anchor bolts on the piers of the short deck span have been pulled out, apparently by contraction. This is shown in Fig. 5. Whether this action is due to the suspension and contraction of the truss under the heat or whether the falling pieces spalled the concrete so that there was not sufficient bearing to hold the bridge is not known. Damage is estimated at $250,000.

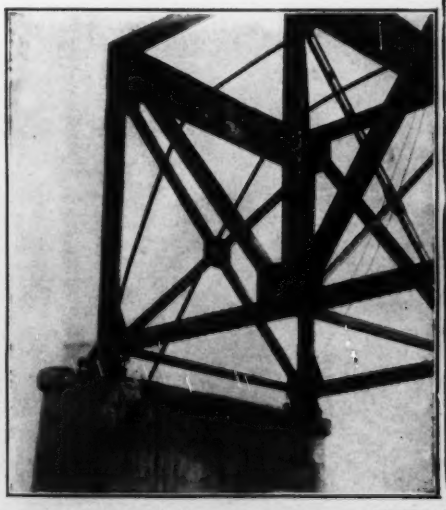


FIG. 5. EAST PIER AFTER THE FIRE, SHOWING SPALLING OF PIER AND MOVEMENT OF SHOE

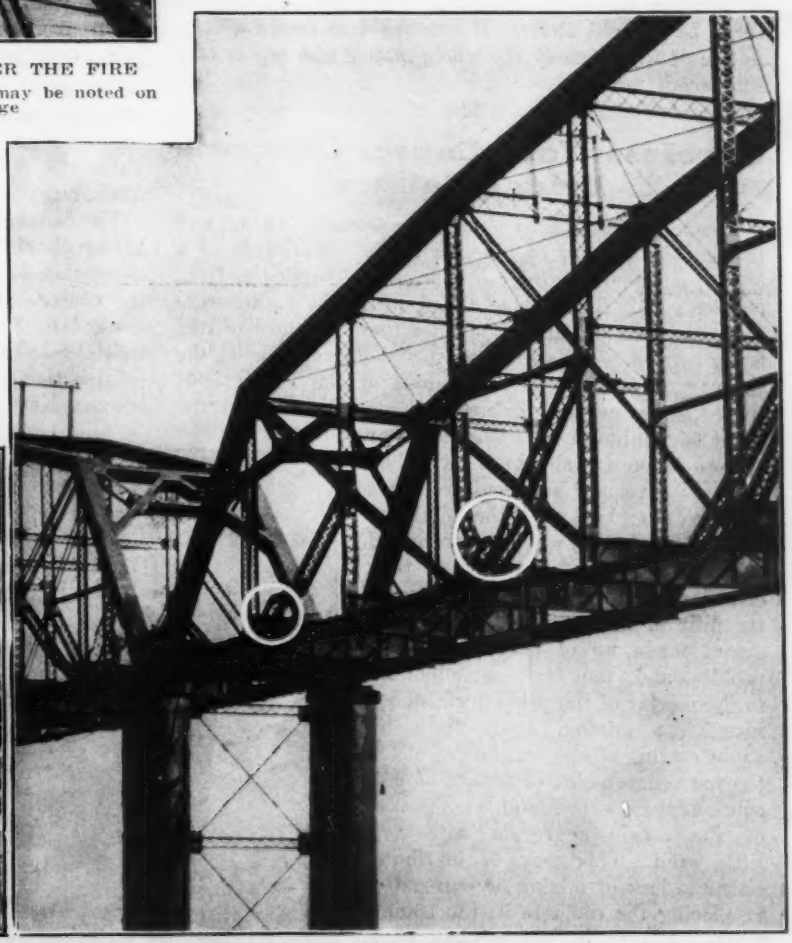


FIG. 4. CLOSE-UP VIEW SHOWING SERIOUS BUCKLING OF MEMBERS ON NORTH TRUSS
Circles indicate the points at buckling

An Organization of Engineers for Public Service

A luncheon was given by William L. Saunders, Chairman of the Ingersoll Rand Co., in New York City on Sept. 28, to consider plans for the formation of an organization "to bring the engineer forward to a position of influence in the affairs of government." Those present at the luncheon included the presidents and secretaries of the national engineering societies and the American Chemical Society, with a number of other well-known engineers.

The underlying thought on which the discussion at the luncheon was based was that a complete nation-wide organization of engineers has been created by the Naval Consulting Board, through its committee on Industrial Preparedness, and has demonstrated the value of the expert service of engineers in connection with the Government's needs. Ought there not to be a permanent organization of engineers, free from the rules and regulations which govern the professional societies, which could make its voice effective when Congress is considering such questions as conservation of natural resources, mining laws, railroad regulation and other questions which call for national and state legislation?

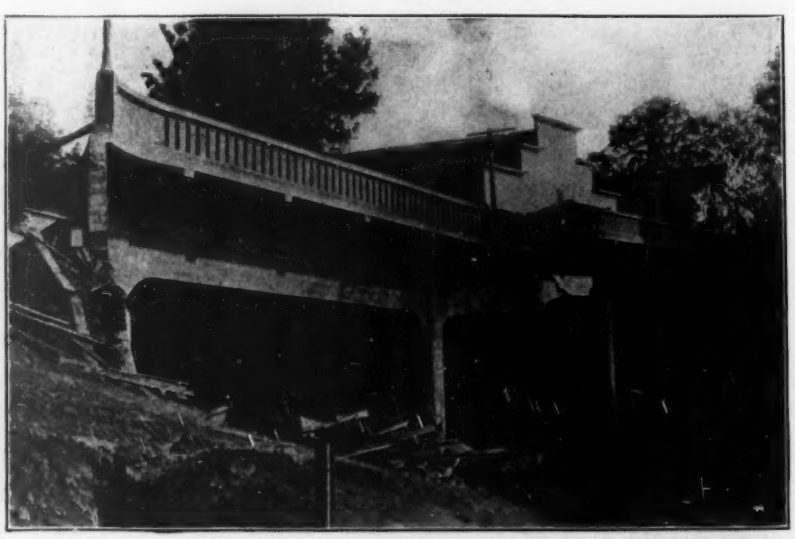
Various opinions were expressed in the discussion which followed the luncheon as to the best methods by which coöperation among engineers to effect the ends desired could be brought about. It was voted to create a committee of five to study the whole matter and report at a subsequent meeting.

⁂

Careless Work Causes Concrete Bridge Failure

A combination of poor materials, improper mixing, and the careless placing of concrete caused the failure of a reinforced-concrete girder bridge at Independence, Ore., on Sept. 21. The bridge failed while the forms were being stripped and at a time when there was no live-load being carried. The accompanying photograph shows the manner of failure. Both columns of the nearer bent settled, shearing the girders of the middle span at the point of minimum resistance to shear. After dropping about 4 ft. these columns developed sufficient resistance to carry the load and the total collapse of the bridge was thus prevented. An examination of the base of these columns indicates the probable cause of the failure. The aggregate was a river gravel made up of generally smooth pebbles and the lack of adherence to the mortar of the pebbles was due to insufficient mixing, apart from the slight coating of clay on the gravel. At the immediate point of failure of both columns there were found large pockets of the coarse aggregate with very little sand. This may be attributed either to lack of mixing or segregation in placing the concrete in the column form. A sign of the careless work, which also without doubt was one cause of the failure, was the presence of a piece of 2x8-in. shiplap about 2 ft. long embedded in the concrete of one column near the point of failure.

The broken columns were reinforced with four ¾-in. bars at the corners and wire wrapping. The unit stress under dead-load was about 200 lb. per sq.in. The County Court under whose direction the bridge was built did not deem it necessary to have any engineering supervision of the construction, and the work was done without an inspector. The question of the responsibility between the county and the contractor for the bridge will probably be decided in court. Repair work will practically involve reconstruction of the entire bridge.



FAILURE OF BRIDGE IN INDEPENDENCE, ORE.

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Progress on Alaska Railroads

Up to Oct. 1 of this year the Department of the Interior reports the following progress in the construction of the new Government railways in Alaska:

During the present year, grading has been completed on the 38-mi. branch to the Matanuska coal field from Matanuska Junction, a point 36 mi. northeasterly from Anchorage, a tidewater point on Cook Inlet, where construction began a year ago, and the rails are now being laid on this branch line. It is anticipated that the line will be completed before the end of the open season. At Moose Creek, a point on the branch line, about 12 mi. from Matanuska Junction, a coal mine has been opened, and coal is now being taken out for the use of the railroad and the town of Anchorage. Clearing and grading are under way on other portions of the line, particularly at points northward from Matanuska Junction, southerly from Anchorage toward Turnagain Arm of Cook Inlet and in the vicinity of Talkeetna (the junction of the Talkeetna and Susitna River about 100 mi. north of Anchorage).

The heaviest work to be encountered on the line is the hard-rock cliffs along Turnagain Arm. Blasting and excavation for line here will be actively pursued during the winter. The Alaska Northern Ry., extending from Seward to Kern Creek, a distance of 71 mi., is being rehabilitated throughout and put into condition to haul construction material for the work along Turnagain Arm between Kern Creek and Anchorage. Clearing and grad-

ing are under way on the northern end of the main line in the vicinity of the crossing of the Tanana River at a point known as Nenana—the aim being to connect the Fairbanks mining region with the Nenana coal fields (a distance of 110 mi.) as early as possible.

By the end of the present working season it is anticipated that at least 85 mi. of new construction will have been completed.

American Company To Build Railways in China

It is announced this week that the Siems-Carey Railway and Canal Co. has concluded a contract to build 1,100 mi. of railway for the Chinese Government. The company in question is controlled jointly by the American International Corporation of New York City, and Messrs. Siems & Carey of St. Paul, Minn. The American International Corporation has already advanced $500,000 to cover the cost of preliminary surveys and investigation, and will finance the construction by the sale of Chinese Government bonds. Under the contract with the Chinese Government, the railway lines are to be built at cost plus a percentage. The work of location and construction is to be under charge of an American chief engineer, who will later supervise the operation of the lines when completed. Americans are also to be employed at the head of the auditing and traffic departments. It will probably be a year before final location surveys will be completed, so that the lines may be placed under construction.

Chemists and Engineers Talk on Sanitary Problems

Nearly 20 papers, mostly on various phases of water-supply and sewage disposal, were read in New York City on Sept. 27 and 28 before the Division of Water, Sewage and Sanitation of the American Chemical Society, under the chairmanship of Edward Bartow, Urbana, Ill.

J. W. Ellms and S. J. Hauser reported the results of some experiments on the loss of head in mechanical filters due to microörganisms. It was found that by manipulating the valves on the piping system the sand could be shaken so as to break up the film of organisms and also stop air binding, thus restoring some of the lost head, lengthening the periods between washing and decreasing the wash water. George W. Fuller related some early experience that corroborated the conclusions of the authors.

A valuable paper by William R. Copeland, of Milwaukee, on "Is the Recovery of Nitrogen from Sewage Sludge Practicable?" dealt largely but not wholly with activated-sludge experience at Milwaukee, which seems to answer the question in the affirmative, Mr. Copeland concluded. Most of the paper and an abstract of the discussion by George W. Fuller and others are given elsewhere in this issue.

A review of the activated-sludge method of sewage treatment was presented by George T. Hammond, of Brooklyn. (See articles by Mr. Hammond in *Engineering News*, Apr. 27 and July 13, 1916, for many of the points made in this paper.)

Stream inspection as an important aid in the control of sewage-treatment plants was advocated by C. B. Hoover, Columbus, Ohio. Such inspection should in some cases extend from 2 mi. above to 25 mi. below the sewage-works outlet and may even include dragging the stream bottom for samples. From the popular viewpoint it is important to learn the opinions of riparian owners as to the effect of the treated sewage on the stream.

Water meters were advocated by Henry Leffmann, Philadelphia, in a paper on "Water Meters in their Sanitary Relations." Meters are particularly desirable where sewage is treated. Leslie C. Frank, Washington, D. C., suggested that the cost of sewage treatment be added to bills for metered water.

R. B. Dole was elected chairman, and H. P. Corson was reëlected secretary. The next meeting will be at Kansas City, Mo., a year hence.

Cement Association Now Has Laboratory Adjunct

The Portland Cement Association has just announced that on Sept. 1 it entered into an agreement whereby it will hereafter jointly operate the Structural Materials Research Laboratory at the Lewis Institute in Chicago with that Institute. This laboratory has been for some time conducting exhaustive researches into the nature and behavior of concrete and cement. It is intended in the future to continue these researches and publish them for the benefit of the industry, and at the same time it is hoped that the laboratory will conduct experimental studies of special importance, some of which may be charged for. The details of this part of the work have not as yet been announced. The laboratory is in charge and will remain in charge of D. A. Abrams, who has had considerable experience, both in the Lewis Institute and in the University of Illinois, with the testing of materials.

Smoke Abatement Convention

The 11th annual convention of the Smoke Prevention Association, held at the Planters Hotel, St. Louis, Mo., on Sept. 26 to 29, gave evidence of the practical and economic results of the anti-smoke movement. The meeting was under the auspices of the Joint Smoke Prevention Committee of St. Louis, which represents the Engineers Club, the Civic League, the Business Men's League and the Women's Organization for Smoke Abatement.

Standard smoke ordinances and standard designs for boiler settings and appliances were presented by the committee on standardization. It was decided that these should be accepted as information, action as to their adoption being deferred until the next meeting, so that there might be ample time for their consideration. Two papers related to smoke from heating plants and the design of heating boilers and furnaces. Others discussed the relation of automatic stokers to smoke abatement, and the relation of chimney draft to boiler and furnace operation.

The effective work of smoke abatement at Pittsburgh received a good share of attention. The method of smoke regulation was described by J. W. Henderson, Chief of the Bureau of Smoke Prevention; and the Soot-Fall investigations made by the Mellon Institute of Industrial Research (University of Pittsburgh) were described and illustrated by John J. O'Connor, Jr. Moving pictures were shown by the Pennsylvania R.R. officials, illustrating the methods of cleaning and building fires in locomotives without causing dense smoke, and also showing heavy

passenger and freight trains running through the city without the emission of smoke. This is effected by the use of special grades of coal and special methods of firing.

One session was devoted entirely to railway work, the papers covering the use of special devices on locomotives, and the methods of firing up at roundhouses, these methods being afterward demonstrated at the yard of the Terminal Railroad Association. The use of powdered coal was dealt with in two papers: One on its use for locomotives, by C. W. Corning, of the Chicago & Northwestern R.R.; and one on a special process of carburization and burning of powdered coal by A. G. Kinyon, of Chicago. In the discussion one speaker stated that in furnaces for heating steel the cost for fuel was 40c. per ton of steel with pulverized coal and $2.25 with oil, while the former increased the daily capacity from 100 to 170 tons.

The President for 1916-17 is W. H. Reed, City Smoke Inspector, Chicago; Secretary, Frank A. Chambers, Assistant City Smoke Inspector, Chicago. The next meeting will be held at Columbus, Ohio, in 1917.

Derailment on an Embankment caused the wreck of a freight train on the St. Louis, Iron Mountain & Southern Ry., near Levesque, Ark., Sept. 24. Two trainmen were killed and two injured.

A Grade Crossing Accident at Detroit, Mich., Oct. 1, caused the death of 10 persons and injuries to a score of others. A freight train on the Grand Trunk Ry. collided with a street car at Forest Ave. and Dequindre St.

The Pennsylvania R.R. Detroit Extension will not cost over $10,000,000, according to an official announcement of President Rea. Very little new line will be constructed, as existing lines are to be used to enter the city.

A 40-In. Water Main Burst near the eastern pumping station, Baltimore (Md.) water-works, at 11 a.m., Sept. 24. According to newspaper reports it was impossible to operate the large valves near the pumping station, and the flow had to be shut off from distant gates.

An Automobile Racetrack to cost $1,000,000 is to be constructed in Pittsburgh, Penn., according to press reports. The race course is to be a two-mile track for motors, with an inside track for horse racing. J. B. Callahan is President of the Pittsburgh Speedway Co., which is financing the work.

Fire Destroyed almost the entire business section of the village of Phœnix, N. Y., Sept. 24. It was impossible to check the flames, for the water-works pumping station adjoined the power plant in which the fire originated, and was among the first buildings destroyed. The damage is estimated at $1,000,000.

Traffic Survey Field Work for the Rapid Transit Commission of Cincinnati has been completed and the statistical data will be available for the Commission about Oct. 15. S. R. Morley is in charge of the compilation of the statistics and F. S. Krug is chief engineer of the Rapid Transit Commission.

The Electrolytic Sewage Treatment Plant at Decatur, Ill., was visited on Sept. 30 by a party of nearly 100 engineers, municipal officials and others. A special train for Chicago took a party of about 80. This is the 1,000,000-gal. demonstration plant of the Landreth electrolytic-lime process described in a letter from W. S. Shields, consulting engineer for the promoters, in a letter in "Engineering News," of Aug. 24, 1916.

Breaks in Two Water Mains, an 18-in. and a 24-in., occurred in Pittsburgh, Penn., Sept. 17. The larger main burst at the corner of Suismon and James St. about 7 a.m., under a pressure of between 75 and 80 lb. per sq.in. The pipe is said to have been cracked the entire length of the broken section. The other break was on Carson St., near the foundry of the Jones & Laughlin Steel Co. The pressure on this main was about 85 lb. per sq.in. No extensive damage was done in either case.

Nuisances on the Quequechan River at and near Fall River, Mass., are to be investigated by a commission which is to report its findings and make recommendations as to the construction of drains and sewers and other improvements by Apr. 1, 1917. The report will be addressed to the City Council of Fall River. Joseph Turner, of Fall River, has been made Chairman of the Commission, and H. K. Barrows, 6 Beacon St., Boston, is consulting engineer.

Typhoid Fever Deaths in Boston numbered only 12 for the first eight months of 1916 and of the 12 three were nonresidents. There were 158 deaths in the calendar year 1908, 66 in 1914 and 40 in 1915. The typhoid death rate per 100,000 for the period 1906-10 was 16, while for the year 1914 it was 9.2 and for 1915, 5.3. For the current year it is hoped that the rate will not exceed 2.5, which would allow for an increase in the monthly rate during the last remaining part of the year.

Committee on Engineering Coöperation—Conforming to resolutions adopted at the second annual conference of the Committee on Engineering Coöperation, held in Chicago last April, Chairman F. H. Newell has selected Hunter McDonald, Isham Randolph, Morris L. Cooke and C. E. Drayer to act with him as a subcommittee on plan to be presented for formal consideration at the third conference. A draft of a plan is being considered by the subcommittee which expects to hold a meeting for its further discussion probably in October.

The Park Avenue Viaduct, Cincinnati, Ohio, will be dedicated on Oct. 7. The structure is of reinforced concrete and provides a 40-ft. roadway with two 12½-ft. sidewalks, all supported on a three-ribbed arch of 180-ft. span. The viaduct is the connecting link between Walnut Hills and Eden Park. Its cost, exclusive of engineering, was about $132,000. Frank L. Raschig was principal assistant engineer, F. S. Krug, chief engineer, and D. P. Foley, contractor. The contractor's plant was described in "Engineering News" Apr. 6, 1916, p. 659, and the structure itself replaced by the new viaduct in May 18, 1916, p. 936.

Flood Control in the Miami River is the subject of a hearing in progress this week before the Conservancy Court at Dayton, Ohio. The plan on which the hearing is being held is that submitted to the Miami Conservancy District by Chief Engineer Arthur E. Morgan and adopted by the Board of Directors May 10, 1916. The court before which the hearing is held consists of nine judges acting under the new Conservancy law. Among the prominent engineers whose testimony will be given before the court at the hearing, in addition to those of members of the Morgan Engineering Company's staff, are Gen. H. M. Chittenden, of Seattle, Gen. W. H. Bixby, of Washington, Prof. D. W. Mead, of Madison, John W. Alvord, of Chicago, Prof. S. M. Woodward, of Iowa City, T. W. Jaycox, of Denver, Chas. H. Miller, of Little Rock, H. T. Barnes, of Toronto, and F. J. Fischer, of Los Angeles.

Official Load-Line and Bulkhead Rules for use in the construction and operation of American shipping were the subject of a conference at the office of Secretary Redfield, of the Department of Commerce on Sept. 27. At the conclusion of the conference, which was attended by the principal men in the shipbuilding and ship operating industry in the United States, Mr. Redfield named a preliminary committee of three to select a permanent committee of seven members to formulate a general policy for load-line and bulkhead rules. These rules when formulated will be passed upon by the Department of Commerce, by the new shipping board, and ultimately by Congress. The members of the committee of three are Stevenson Taylor, President of the American Society of Naval Architects and Marine Engineers, Alfred G. Smith, President of the New York and Cuba Mail S. S. Co., and Homer L. Ferguson, President of the Newport News Shipbuilding and Dry Dock Co.

PERSONALS

Edwin Doepers, formerly an architect of Indianapolis, has been appointed City Engineer of Bloomington, Ind., as a salary of $1,200 per annum.

Charles M. Farrow, recently Assistant County Engineer of Montgomery County, Alabama, has been made County Engineer of Limestone County.

Atwood L. Bliss has been appointed Engineer to assist the Director of Wharves and Docks of Philadelphia, Penn., succeeding Richard A. McSadden.

William H. Cummings, formerly of Providence, R. I., has entered the employment of the Waugh glazing department of the Asbestos Protected Metal Co., Pittsburgh, Penn.

Elmer Irving, Supervisor of the Pennsylvania R.R. at Lancaster, Penn., has been promoted to be Division Engineer of the Trenton division, succeeding A. W. McClellan, transferred.

M. J. Graham has been appointed County Road Engineer of Jefferson County, at Beaumont, Tex., succeeding George W. White. Mr. Graham's salary has been fixed at $3,000 per annum.

O. M. McNeil, a graduate of the University of Colorado, formerly with the American Bridge Co., has been appointed Instructor in Structural Engineering at the University of Michigan.

C. H. Niemeyer, Division Engineer of the Pennsylvania R.R. at Pittsburgh, Penn., has been promoted to be Assistant Engineer of Maintenance-of-Way, with headquarters in Philadelphia, succeeding A. B. Clark, promoted, as noted elsewhere.

Charles T. Harris, formerly Secretary of the Hollow Building-Tile Manufacturers' Association of America, has joined **E. Elmo Martin** and **John E. Morris** to form the Martin-Morris-Harris Co., Cleveland, Ohio, to conduct a business service bureau.

M. H. Cahill, Superintendent of the Cumberland division of the Baltimore & Ohio R.R., has been promoted to be General Superintendent of the Pennsylvania district of the company at Pittsburgh, Penn., succeeding E. A. Peck, who has been granted leave of absence.

William L. Darling, M. Am. Soc. C. E., whose resignation as Chief Engineer of the Northern Pacific Ry. was noted in these columns last week, has opened an office in St. Paul, Minn., as a consulting engineer, specializing in railway engineering and construction.

Thomas R. Tarn, formerly Division Engineer of the mechanical division of the Bureau of Water-Supply of the City of Pittsburgh, Penn., has resigned to become Assistant General Manager of James Rees & Sons Co., marine engine and steamboat builders, Pittsburgh.

A. R. Ayers, recently Principal Assistant Engineer of the equipment department of the New York Central Lines, New York City, has been appointed Superintendent of Motive Power of the New York, Chicago & St. Louis R.R., with headquarters at Cleveland, Ohio. He is a mechanical engineering graduate of Cornell University, class of 1900, and began his railway experience as a special apprentice of the Lake Shore & Michigan Southern Ry.

William J. Cunningham, Assistant to the President of the Boston & Maine R.R., has been appointed Professor of Transportation at Harvard University. This professorship was established to commemorate the work of the late James J. Hill and is known as the Hill professorship. Professor Cunningham was born at St. John, N. B., Apr. 29, 1875. His railway experience began in 1892 as a stenographer with the Canadian Pacific Ry.

A. B. Clark, formerly Assistant Engineer of Maintenance-of-Way, Pennsylvania, R.R., Philadelphia, Penn., has been appointed Superintendent of the Renovo division, succeeding the late J. M. James, who died Sept. 17. Mr. Clark graduated from Lafayette College in civil engineering in 1891. He entered the service of the Pennsylvania R.R. as a rodman in 1891, and has been with this railway continuously ever since. For nine years, 1901 to 1910, he was Division Engineer of the Renovo division.

George A. Kyle, Assoc. M. Am. Soc. C. E., Consulting Engineer, Portland, Ore., has been appointed Engineer in charge of location and construction of the railways to be built in China by the American International Corporation and the Siems-Carey Railway and Canal Co., as noted on p. 672 of this issue. He will work with officials of the Chinese Government in deciding upon the lines to be built. Mr. Kyle has been associated with John Hays Hammond, Mining Engineer, in the Rand, South Africa, and has had railway building experience in Alaska. Recently he was with the Northern Pacific Ry.

OBITUARY

Robert H. Boynton, Jun. Am. Soc. C. E., City Engineer, of Frankfort, Ind., died Sept. 18. He was born at Batavia, N. Y., May 21, 1886. He was graduated in civil engineering at the University of Michigan in 1910. His first engineering experience was with the Missouri Pacific Ry. and with the United States Government. He was appointed City Engineer of Frankfort in 1913.

ENGINEERING SOCIETIES

EFFICIENCY SOCIETY OF AMERICA.
Oct. 7-9. Annual meeting at New York City. Secy., G. E. Burroughs, Pittsburgh, Penn.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 9-13. Convention in Newark, N. J. Secy., Charles C. Brown, Indianapolis, Ind.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.
Oct. 9-13. Convention at Atlantic City, N. J. Secy., E. B. Burritt, 8 West 40th St., New York City.

IRRIGATION CONGRESS.
Oct. 14-24. 23rd International Irrigation Congress at El Paso, Tex. Secy., Arthur Hooker, El Paso.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 17-19. Convention in New Orleans. Secy., C. A. Lichty, C. & N. W. Ry., Chicago.

AMERICAN GAS INSTITUTE.
Oct. 17-20. Annual meeting in Chicago. Secy., G. G. Ramsdell, New York, N. Y.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 24-27. Annual convention at Cincinnati, Ohio. Secy., Prof. Selskar M. Gunn, Boston, Mass.

RAILWAY ELECTRIC SUPPLY MANUFACTURERS' ASSOCIATION.
Oct. 30-Nov. 3. Annual meeting at Chicago. Secy., J. Scribner, General Electric Co., Chicago.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 14. Convention in Washington, D. C. Secy., W. H. Connolly, Washington.

RAILWAY GARDENING ASSOCIATION.
Dec. 5-7. Annual meeting in New Orleans. Secy., Charles E. Lowe, Sewickley, Penn.

PORTLAND CEMENT ASSOCIATION.
Dec. 11-13. Annual meeting in New York City. Assistant to General Manager, A. H. Ogle, Chicago, Ill.

The American Institute of Architects will hold its annual convention in Minneapolis, Dec. 6 to 8. The secretary is Burt L. Fenner, The Octagon, Washington, D. C.

The American Institute of Chemical Engineers will hold its annual meeting in New York City, Jan. 10 to 13. The secretary is J. C. Olsen, Cooper Union, New York City.

The Society of American Bacteriologists will hold its annual meeting in New Haven, Conn., Dec. 26 to 28. The secretary is A. Parker Hitchens, Glenolden, Penn.

The American Wood Preservers' Association will meet in New York City at the Hotel Astor, Jan. 23 to 25. The secretary is F. J. Angier, Mt. Royal Station, Baltimore, Md.

The Bridge Builders and Structural Society will probably hold an annual meeting on Jan. 12, in New York City. The secretary is George E. Gifford, 50 Church St., New York City.

The National Municipal League will hold its annual meeting in Springfield, Mass., Nov. 23 to 25. The secretary is Clinton Rogers Woodruff, 705 North American Building, Philadelphia, Penn.

The Chattanooga Engineering Society has been organized with 92 members. Already there are 40 applications. It is reported that G. W. Knight, of Knight & Quayle, consulting engineers, led the organization movement. The new society will hold two luncheons each month.

The International Irrigation Congress will hold its twenty-third session at El Paso, Tex., Oct. 14 to 24, which includes also the International Farm Congress and the International Soil Products Exposition. On Saturday, Oct. 14, the Elephant Butte dam of the Rio Grande project, United States Reclamation Service, will be dedicated. One of the attractions of the congress will be the maneuvers of 60,000 soldiers, who are sojourning in the vicinity of El Paso. The secretary of the congress is Arthur Hooker, El Paso.

American Railway Bridge and Building Association—The twenty-sixth annual convention, to be held in New Orleans, La., has a three-day program commencing Oct. 17. Subjects of reports and discussions are: Water-supply; floors for shops and roundhouses, etc.; paint and its application to railway structures; caring for and handling creosoted materials; blank forms for bridge and building departments' use; modern methods of driving piles; fireproofing roofs of wooden buildings; efficient methods of handling work and men; station buildings for passenger service only; economical handling of concrete on smaller jobs; and small coaling stations. The headquarters of the convention will be Hotel Grunewald. The secretary is C. A. Lichty, Chicago & Northwestern Ry., Chicago, Ill.

Iowa and Illinois Sections of American Water-Works Association—A joint session will be held Oct. 10 and 11 at Davenport, Iowa, Rock Island and Moline, Ill. The headquarters will be the Hotel Blackhawk, Davenport. The program includes a round-table discussion of water-works practice and experience and several papers of unusual interest, including one on "Experience with Trenching Machines on the French and Russian War Fronts," by A. E. Miller, of Des Moines. Excursions include visits to the filter plant of the Rock Island arsenal, the main pumping station of the Davenport Water Co., the filter plant of the Rock Island water-works and the pumping station and filter plant of the Moline water-works. All water-works men are invited. James P. Donahue, Davenport, is chairman of the local committee.

Appliances and Materials

Compressed-Air "Paint Gun"

A new design of compressed-air paint sprayer has been recently developed by the Spray Engineering Co., of Boston, Mass. It is intended particularly for rapid work and uniform paint, varnish or lacquer coatings on machines and metal parts. A painting outfit comprises the gun itself, connected by hose to the paint container and an air filter. The tank carries the pressure-control attachment and gage. The gun itself looks like a stubby automatic revolver; the control is by a trigger that governs both the air and the material supply. A nose cap adjusts the supply of material, and a rear stem regulates the air. The control head on the paint container shows the pressure on the air line and on the material.

SPRAY PAINT GUN

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Patented Words—Patents have been granted the Permutit Co., New York City, covering several words used in connection with the company's trademark. The words "permutize," "permutized," "zerowater" and "zero-hardness" may be used only in referring to the Permutit Co. This company makes a special type of filter for water softening.

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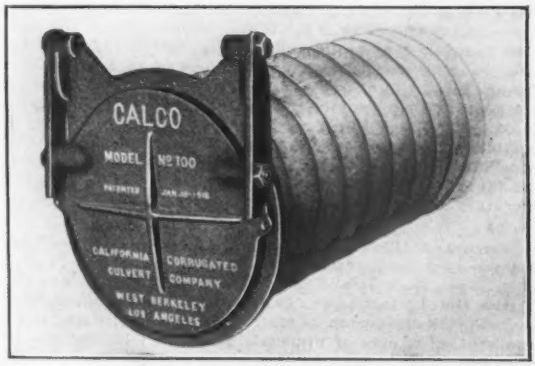
Automatic Flap Valves

Automatic flap valves have long been used in drainage work, particularly in the Mississippi Valley. They are designed to open under a slight pressure from within the pipe and to close automatically with any pressure from without.

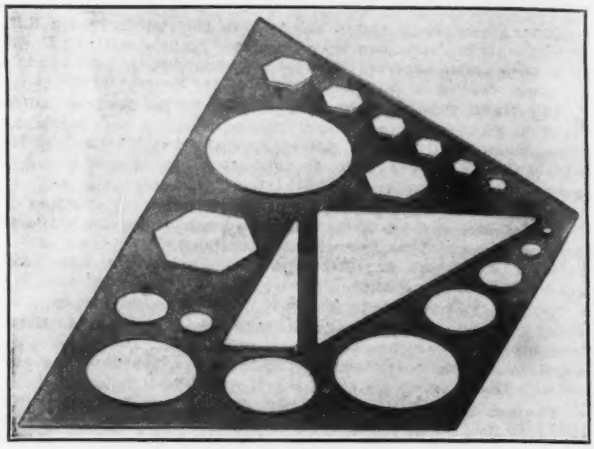


PATENTED FLAP VALVE MADE IN LOS ANGELES

The California Corrugated Culvert Co., of Los Angeles, Calif., has placed on the market a patented cast-iron valve for use on corrugated sheet-metal pipe. The flap is hinged from the upper part of the casting, as shown in the accompanying illustration.

An Isometric Drawing Form

The drawing instrument shown in the accompanying illustration has been recently put out by the Two Rivers Drawing Tools Co., of Two Rivers, Wis., as an aid to isometric projection of geometrical forms. It is claimed that a greater variety of uses for the forms is found than is obvious at first.

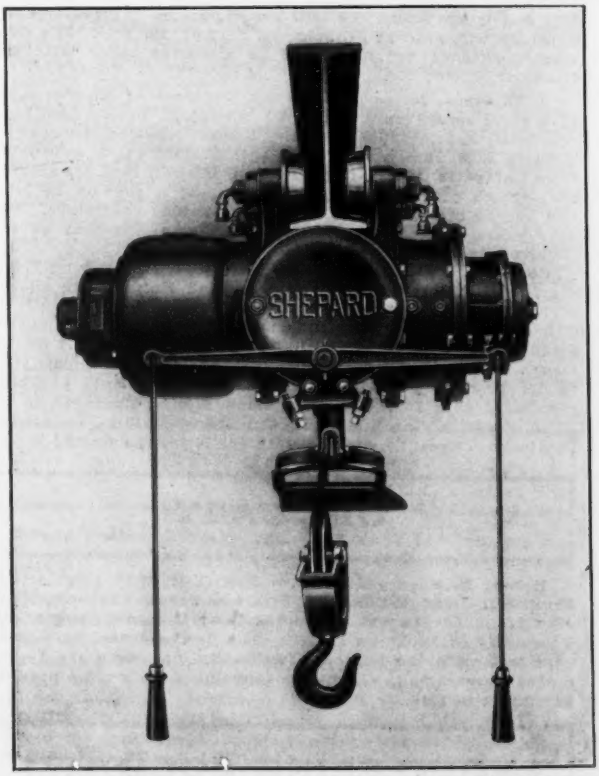


FORM FOR ISOMETRIC DRAWING

* * *

Monorail Traveling Hoist

A small single-speed traveling hoist for monorail lines, but with the same completeness of detail that marks the largest cranes, has been designed by the Shepard Electric Crane and Hoist Co., of Montour Falls, N. Y. The general appearance can be found from the accompanying figure. The brake is a combined mechanical and electrical type that regulates the braking action according to the load. The hoist is in four parts—(1) the winding or center section, (2) the motor end, (3) the gear and brake end and (4) the controller. Each section is a complete unit, and the pieces are bolted together. Three sizes are made, the capacities being of 500, 1,000 and 2,000 lb.



SHEPARD MONORAIL TRAVELING HOIST